REPORT
OF THE
ORISSA FLOOD
COMMITTEE

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WILLIAMS

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GOVERNMENT OF BIHAR AND ORISSA.

IRRIGATION DEPARTMENT.

RESOLUTION.

Dated Patna, the 25th November 1927.

SUBJECT.—Appointment of a Committee to enquire into the flood problems of Orissa.

THE three coastal districts of Orissa, a deltaic strip of country through which many important rivers from the interior find their way to the sea, have from time to time been visited by floods of greater or less intensity. Since the year 1855 many special enquiries have been made with a view to prevent, or diminish, the intensity of these floods; in the majority of cases attention was focussed on problems of the Mahanádi, a river which chiefly affects the Puri and Cuttack districts, but the floods of 1920 drew special attention to the Brahmini, Baitarani and other rivers which caused severe damage in Cuttack and Balasore. A contour survey of the whole coastal tract was made between the years 1920—23 and a committee, appointed at the instance of the Legislative Council, investigated the question of possible palliatives and reported in 1924. But there has not so far been an authoritative review of the flood problem as a whole by recognized experts and the Governor in Council considers that the first essential to any concerted remedial action is a reasoned statement of the problem by a body of men who are experts in dealing with river action and who are qualified to advise as to which of the many factors in operation are of prime importance and in what direction remedial action can be sought with greatest prospects of success. His Excellency in Council has therefore sought the help of the Government of India in constituting such a committee and that Government have consented to lend the services of Mr. D. G. Harris, C.I.E., Consulting Engineer to the Government of India, and the Government of Bengal have allowed Mr. C. Addams Williams, C.I.E., Chief Engineer to the Government of Bengal, Irrigation Department, to act as members; the third member will be Rai Bahadur Bishun Svarup, Chief Engineer to the Government of Bihar and Orissa, Irrigation Department. Mr. G. Stevenson, Executive Engineer, Irrigation Department, Bihar and Orissa, will act as Secretary.

The committee after studying existing records will meet at the beginning of January and will examine the problem on the spot. It is not the intention that the committee shall generally take formal evidence, but it is recognized that many conflicting interests will be affected by any measures that may be proposed by the committee for regulating or altering the distribution of flood water and the committee will therefore place themselves in touch with people of all classes who are directly affected by the floods and whose personal knowledge and views will be of assistance to them in their work and may influence their decisions. The District Magistrates have accordingly been instructed to take steps to ensure that the committee are placed in possession of the various views of those interested.

The terms of reference to the committee are :—

> To investigate the nature of the flood problem in Orissa and to assess the importance of the various causes and to advise as to the direction in which a solution can most profitably be looked for and the steps which should be taken either in the nature of remedial measures or further investigation.

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ORISSA FLOOD COMMITTEE, 1928.

Chairman.

Mr. C. Addams Williams, C.I.E., M.I.E. (Ind.), Chief Engineer to the Government of Bengal.

Members.

Rai Bahadur Bishun Svarup, B.A., late Chief Engineer to the Government of Bihar and Orissa.

Mr. D. G. Harris, C.I.E., M.I.E. (Ind.), Consulting Engineer to the Government of India.

Secretary.

Mr. J. Shaw, B.SC., Assistant Executive Engineer, Public Works Department, Irrigation Branch, Bihar and Orissa.

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REPORT

OF THE

ORISSA FLOOD COMMITTEE,

1928.

CHAPTER I.

Introductory.

Our Committee was constituted in Resolutton No. 4741—XC-6-27-I., dated the 25th November 1927, of the Government of Bihâr and Orissa, Irrigation Department, which is reproduced on the first page and in which the terms of reference to us are stated. In accordance with this Resolution we assembled in Cuttack on the 6th January 1928, and spent that month in recording evidence and in touring through the affected tracts.

2. It soon became evident to us that we should be unable to submit anything in the nature of a complete report within the time originally allotted to our enquiry. Several considerations constrained us to this view. In the first place, our days were so fully occupied with inspections, the hearing of evidence, and the holding of meetings that there was but little opportunity for any detailed examination and discussion of the material collected. In the second place, we deemed it desirable that we should have time, after our tour, to re-read and re-digest the enormous literature which has grown around the subject, much of which was unintelligible until the various works and places mentioned had been visited. In the third place, we found that it was necessary to obtain a considerable amount of additional information, in the form of surveys, cross-sections, etc., and to have portions of the information already available properly compiled, before we could attempt to arrive at final conclusions. An aerial survey of the Orissa coast had also recently been made which, when completed, would, we thought, be of value in dealing with the mouths and estuaries of the rivers, especially those which we had not had the opportunity of inspecting personally. Lastly, we felt that a tour of the affected tracts during the monsoon was a necessary preliminary to any report upon floods in Orissa. We therefore suggested, a suggestion which the Governor in Council was pleased to accept, that our Committee should merely adjourn in February, to re-assemble in July.

3. Before our adjournment, we addressed a letter to the local Government dealing with certain matters which had either been specifically referred to us for advice or which had come to our notice during our tour. In order to bring the whole subject within a single report, we have repeated the substance of this letter in the chapters which follow.

4. We re-assembled at Contai Road on July 24th and entered Orissa *via* the Coast Canal. On reaching Chandbali we found that both the Brahmini and Baitarani were in flood, so had an opportunity of seeing for ourselves the conditions which obtain at such times on these rivers. During the course of our tour in the Puri district we further succeeded in visiting certain of the rivers which we had not been able to inspect during the winter, owing to the volume of water in them having been insufficient to float a boat. We returned to Cuttack on August 13th to write our report.

5. A brief diary of our two tours is annexed as Appendix I. In the course of our inspections we have covered nearly 2,200 miles, having thus done our best to see so much of the area to be dealt with as was possible in the time at our disposal. We are aware that disappointment has been expressed by the inhabitants of certain outlying portions of the country that we have been unable to visit them and see their problems on the ground, but it was quite impossible for us to proceed to every flooded area, especially in view of the lack of any even reasonably rapid means of communication which obtains in many parts of Orissa. To have inspected some of these places would have meant journeys extending over days by row-boat and palanquin. We have, however, carefully considered the representations as to their conditions made by the people in question and believe that they are in every case covered by the general recommendations which we make. It was never the intention that we should carry out an exhaustive enquiry into the local problems of each tract; this will have to be done hereafter by a special staff, working on the lines of our general proposals, if the latter are accepted.

6. In the Resolution in which our Committee was convened it was stated that we should not, generally, take formal evidence. Early in our proceedings, however, we decided to do so as otherwise we might have been left in doubt as to whether we had heard every side of the questions referred to us. We therefore recorded the evidence of 48 gentlemen, both officials and non-officials, a list of whom forms Appendix II. They include, among Government servants, the Commissioner of the Orissa Division, the three Collectors of the three districts, two Settlement Officers, three Civil Surgeons, four Civil Subdivisional Officers, five Public Works Department Officers and an Agricultural Officer. Among non-officials they include four chairmen and vice-chairmen of district boards, three District Engineers, nine Rajas, Zamindars and Managers, representative of all the larger estates in Orissa, one officer of the Feudatory States, one of the Bengal Nagpur Railway, and eleven representative public men. The evidence thus taken is being printed as an accompaniment to our report. We have not thought it necessary to print the mass of written representations, many of them in the vernacular, which we have received, both from public bodies and from private persons, on subjects pertaining to our enquiry; they have all been carefully considered and will be forwarded to the local Government with our report for record.

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7. We had the advantage, while at Puri in January, of meeting the Working Committee of the Orissa Flood Conference and of discussing with them the replies received to a questionnaire on the subject which they had recently circulated throughout Orissa. It was with the greatest regret that we learnt, in the interval which elapsed before our second visit, of the death of Pandit Gopabandhu Das who led the Committee and who also gave evidence before us separately.

8. We held six public meetings, at Jajpur, Balasore, Bhadrak, Alba, Cuttack and Puri, at which it was open to any one who so desired to come forward and explain his troubles or his views; these meetings were well attended and we were glad to see the cultivating classes taking these opportunities to ventilate their grievances. Even more gratifying was the response to our invitation, issued through the civil officers, to all concerned to meet us, during our tour, at places or works in which they were particularly interested and to explain their difficulties on the spot. We held upwards of a hundred informal discussions of this kind, sitting on an embankment or under a convenient tree; according to the interest of the matter immediately under discussion the attendance ranged from twenty or thirty to several hundred cultivators. There was complete liberty of speech at these discussions, the only check on loquacity being that nobody was permitted to repeat what had already been said. Information of the utmost value was often elicited in the course of meetings such as these.

9. We have, in short, throughout our tours, attempted to afford to all with whom we came in contact a chance to represent their case, so that we might hear every side of the difficult problems which we have been charged to investigate.

CHAPTER II.

The physical features of Orissa.

10. The portion of Orissa to which our enquiry relates includes the greater part of three civil districts, Balasore, Cuttack, and Puri, an area of about 8,000 square miles. In shape, the area in question is not unlike the segment of a circle, the sea-coast forming the arc and the foot of the hills the chord. In the north of Balasore and in the south of Puri the hills descend almost to the coast ; between these extremes lies the segment-shaped plain to which reference has been made which, at its broadest point in the Cuttack district, attains a width of some sixty miles.

11. The plain in question is divided into two well-defined tracts, the salt tract which fringes the coast, and the arable tract behind it. In Balasore, the salt tract consists of a desolate strip of country a few miles broad ; high sandy ridges rise from the beach, often in succession one behind another, giving evidence of the position of the sea-coast in past days. Lower down, in Cuttack, the scenery changes, and the tract becomes a region of swamp and dense jungle, intersected by rivers and drains, in appearance not unlike the Bengal Sunderbans ; it is here that it attains its greatest width of about twelve miles. Still further down, in Puri, its character alters again and it assumes the form of a bare belt of sandy ridges which stretches along the sea-shore for the full length of the district, varying from four miles to a few hundred feet in width.

12. Behind this salt tract is the arable tract, the amelioration of the condition of which is the main object of our investigation. Lying between the salt tract and the hills, it consists of a great level plain of rice-fields, dotted with villages and watered by a complicated network of streams and rivers.

13. It is these rivers which form the principal physical features of Orissa ; indeed it is to them that the country owes its origin. The main rivers are five in number, the Subarnarekha, the Burabalong, the Baitarani with its tributary the Salindi, the Brahmini and the Mahanadi. Of these, the Burabalong presents no particular problems ; both the Burabalong and the Subarnarekha, which run through the north of the Balasore district, have but comparatively short courses between the hills and the sea and, although we shall have occasion to deal with the floods in the Subarnarekha, this is rather because the task of suggesting remedies for these floods has been specifically laid upon us than because they form part of the main flood problem of Orissa. This problem is confined to the floods of the Baitarani, Brahmini and Mahanadi. We shall deal with each of these rivers in turn but, before doing so, we propose to give a short general description of the features of these rivers which are common to all of them.

14. The three rivers in question enter the Orissa plain from the hills of the Feudatory States, emerging with high velocities and, during the monsoon, charged with large quantities of silt. On entering the plains, this velocity is checked, and, being reduced to a point where the water can no longer carry the whole of the matter suspended in it, silt is deposited in the river bed. As the bed rises, the flood levels also rise ; the water spills over either bank, and, by depositing silt on the land in the immediate vicinity, builds up a ridge on the summit of which the river flows. This process continues until a position of unstable equilibrium is reached, when the river bursts its bank and throws out a branch into the valley which has been formed between it and the next river ridge, which valley is then similarly raised by silt deposit until, in due course, the process is repeated. It is thus that the typical features of a deltaic country come into existence, the rivers running on ridges with lower land between them, constantly overflowing their banks, and casting off a network of branches until, in many cases, it is only convention which decides which branch, if any, shall maintain the name of the parent stream.

15. These deltaic characteristics are very noticeable in Orissa. The three rivers already referred to enter the plains through three gorges in the hills. Half way between the gorges and the sea they have subdivided into fifteen main branches and innumerable minor streams, eventually reuniting and flowing into the Bay of Bengal through six major estuaries. On their way their waters become inextricably mingled ; thus part of the Mahanadi water flows *via* the Birupa into the Brahmini and thence into the Dhamra, the northernmost estuary, while part flows *via* the Katjuri, Koakhai and Bhargovi into the Chilka Lake and so into the sea on the southernmost boundary of the province.

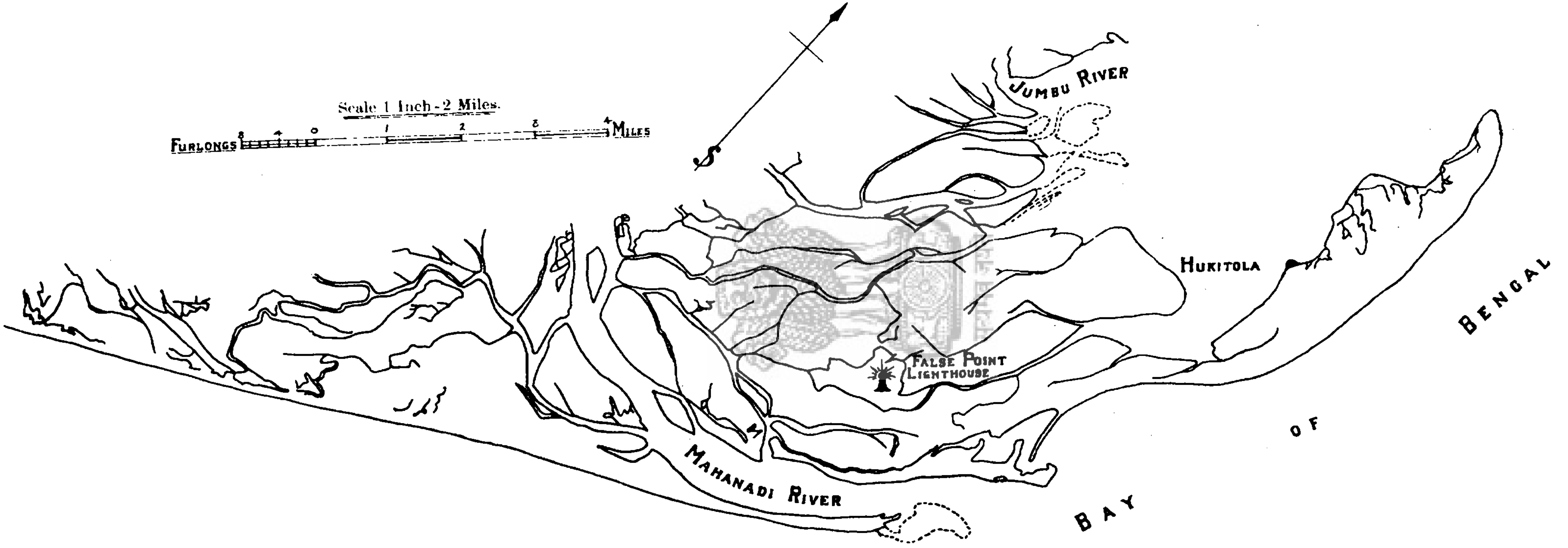
16. As almost invariably happens in inhabited deltas, the position has been complicated by attempts to protect the arable area from flooding due to the spill of the rivers. It has been calculated that the Mahanadi, the largest of the series, discharges, in maximum flood. about one and a half million cubic feet of water a second where it emerges from the hills above Cuttack, while, if a circle of 25 miles radius be drawn with its centre at that place, the branches of the Mahanadi, where they cross that circle, are capable of carrying only half that volume; this diminution in discharge capacity is typical of all deltaic rivers. The other half has thus, necessarily to flow over the surface of the country ; it is the silt in this water which, in the ordinary course of nature, goes to raise the surrounding land. Artificially to restrict this spill area entails, of course, a deepening of the spill water where no such protection is given and excessive flooding is the result.

17. It must be clearly grasped that, in a deltaic area, there must be flooding ; it is nature's method of land formation, and any efforts to prevent it are doomed to failure from the outset. It might, for example, be suggested that every river should be embanked on both sides from the point where it leaves the hills to the sea ; the result would merely be that it would deposit silt in its bed, the bed would rise, the floods would rise and the embankments have to be raised to correspond, until eventually these embankments would reach a size at which they could no longer be maintained. They would then burst, probably to the complete destruction of the country in the vicinity which would have been becoming lower and lower relatively to the level of the water in the river. Much the same phenomenon occurs when isolated areas are protected by embankments ; the land around, subjected to an increased spill, tends to rise, the height of the flood is increased. one proprietor raises his embankment, the others are bound to follow suit or be drowned out, and thus the vicious circle goes on until, in many cases, the protected area becomes little more than a low-lying swamp, surrounded by higher land on every side. There comes at last a time when the protective embankments can no longer be maintained ; when this occurs the area behind them is infinitely worse off than is the unprotected area outside.

18. Another physical phenomenon which undoubtedly has a considerable effect upon the floods in Orissa is the variation in the level of the sea owing to the heading up of water in the Bay of Bengal during the south-west monsoon. The effect of this phenomenon is to raise the level of the water at the mouths of the rivers by some 2 or 3 feet, and considerably more during storms. There is a further and even more marked variation in the level due to the tides. The combined result is to reduce the slope of the water flowing down the rivers, with a corresponding reduction in their capacity for discharge. It is noticeable that several of the largest floods in the main rivers have occurred at the period of high spring tides.

19. There is a further factor which operates along the sea-coast, namely, the steady northward littoral sand drift. This drift tends to form bars across the mouths of the rivers from south to north ; a bar of this nature is often raised in the hot weather by the prevalent wind so as to form an unbroken sand dune across the mouth some 25 or 30 feet high above sea level. It is not uncommon to find a river pursuing a fairly straight course to the sea, there to be diverted parallel with the coast for several miles before it can succeed in obtaining an outlet. The Sonamuhi,

AERIAL SURVEY OF ORISSA COAST ILLUSTRATING LITTORAL DRIFT



Heliozincographed at the Survey of India Offices Calcutta

for instance, rising in the Samang Pat behind Puri runs parallel with the coast behind the dunes for about thirteen miles and in some years has a common mouth with the Chilka Lake though independent mouths have opened on occasions as high up as Harachandi.

20. The course of the Bhargovi has been similarly diverted. There is little doubt that this river used to discharge into the sea a few miles to the east of Puri. Now, after a circuitous course of over twenty miles, it has a common mouth into the Chilka Lake with the Daya, the mouth of the most westerly branch of the Mahanadi. All along the coast of the Puri district the remains of old courses of rivers can be traced behind the dunes and it is undoubtedly this feature which, to a large extent, accounts for the abnormal flooding in that district. The level of the land inside the dunes is only a few feet above the mean level of the sea and forms a balancing reservoir for the flood water until it can escape through inefficient outlets, situated miles away, either into the sea or into the Chilka Lake. Water levels are consequently raised abnormally. Flood levels in the Samang Pat and Sur Lake, 3 or 4 miles away from the coast, rise to as much as 12 feet above the highest level of the sea. Even should the force of a river during flood burst the bar and open a direct mouth, the littoral drift will close it as soon as the floods fall. Thus the mouth of the Chilka Lake opened to a width of a mile last year but, by the time of our inspection in January, all but three small openings, each a couple of hundred feet wide, had again been blocked with sand. A plan reduced from the recent aerial survey of the coast which illustrates clearly the tendency referred to in the case of the mouths of the Mahanadi will be found on the opposite page.

21. It is very possibly to this drift that one of the most peculiar features of Orissa, namely, the shortness of its deltas, is due. Whereas the heads of the deltas of such rivers as the Ganges and Indus are situated about 400 miles from the sea, the deltas of the Mahanadi, Brahmini, and Baitarani are little more than fifty miles long. It is probable that these rivers are continually striving, by deposit of silt, to form new land on the sea edge but that this silt is continually being forced towards the north by the littoral drift. We consider it likely that to this drift is due, on the one hand, the long shallow shelf which is shown on the charts as stretching into the Bay of Bengal in front of the Orissa rivers, and, on the other, the progressive filling in of the Balasore Roads. This raising of the sea-bed in the north-west angle of the Bay has affected the estuaries of the rivers flowing into the Balasore Roads ; the Subarnarekha bed has deteriorated, and the Dhamra estuary and its outer bar have several feet less water now than they had in 1885.

CHAPTER III.

Observations on certain remedies suggested for mitigating the floods.

22. We propose, in this chapter, to deal with and, we hope, finally to dispose of certain suggestions which have been put before us in evidence but which are, in our view, impracticable or useless. These suggestions were, we are fully aware, made in the best of faith, and are such as might appear, to any one without special technical knowledge, to offer a solution of our problems. We consider it, therefore, to be incumbent upon us to explain why we have found them unacceptable.

23. A proposal, which has been very strongly urged in several quarters, is that reservoirs should be built on the rivers, in the country lying above the delta, in which all water which cannot be passed to the sea without flooding should be stored, the water being released again as soon as the rivers fall below flooding point. The sponsors of this suggestion have probably failed to take into consideration the enormous volume of water carried by the Orissa rivers. In the absence of proper hydrographs we are not in a position to say exactly how large the reservoirs would have to be, but, to deal with the Mahanadi alone, it would be necessary to impound at least a hundred thousand million cubic feet and possibly more in order to reduce its discharge to an amount which its various branches can carry. It is most improbable that a site or sites could be found which would permit of the storage of this huge volume of water ; even should such exist, the cost would run into many crores of rupees, as the scheme would, so far as our information goes, constitute by far the greatest storage project in the world.

24. But the gravest defect inherent in any scheme of this nature is the fact that the lives of the reservoirs, presuming their construction to be technically and financially possible, would be extremely limited. The silt-laden water, trapped by the dams, would deposit its sediment and in a comparatively short period the storage capacity of the reservoirs would be reduced to such an extent as to render the works useless. Similar schemes for flood absorption dams have been examined and, in some cases, drawn up in detail in other parts of India but in every case the proposal has had to be dropped on account of this insuperable difficulty. The same remarks apply also to the utilization of the Banki estate as a flood absorption reservoir for the Mahanadi. We are convinced that no solution of the flood problem of Orissa is to be found on these lines.

25. Another proposal which has been suggested by several witnesses is the dredging of the estuaries of the rivers. We have visited and carefully examined the main estuaries through which the Baitarani, Brahmini and Mahanadi run into the sea and are fully satisfied that the trouble does not lie there. They are fine, wide waterways of considerable depth and, except in so far as tidal obstruction is concerned offer no hindrance to the free passage of floods. We have been fortified in this opinion by an examination of their tidal curves.

26. The same cannot be said of the estuaries in the Puri district which, as explained in paragraph 20, are usually masked by sand hills caused by the littoral drift. This is a force of nature against which no amount of dredging will prevail. We have, in the paragraph referred to, mentioned the closing of the newly-opened mouth of the Chilka Lake. So rapid was this action that, standing at the mouth, it was actually visible to the eye ; every wave brought its quota of sand and deposited it on the ever-lengthening spit. We are not prepared to say that it is impossible to assist nature in her efforts to discharge the water of the rivers into the sea on a more direct alignment by excavating cuts through the dunes at carefully selected points and protecting them, by breakwaters or plantations of casuarina trees, cactus, goatsfoot creeper, etc., from the drifting sand, leaving it to the floods to widen and maintain such cuts. We consider, indeed, that further experiments should be made in this direction, and in Chapter XII

we have made detailed suggestions in regard to the release of flood water round Puri by a cut from the Sur Lake. Government should, we think, be prepared to spend money on experiments of this nature.

27. Similarly, to dredge the courses of the rivers, as has sometimes been suggested, is to attempt to challenge deltaic action and would inevitably be doomed to failure. The sand would deposit again as quickly as it could be removed. Equally ineffective would be any attempt to shorten the course of a river carrying heavy sand by cutting through its loops. The formation of loops is a natural tendency, depending largely upon the velocity of the water and the nature of the soil through which the river flows ; even were such loops cut through, the river would not maintain a straight course but would merely form new loops elsewhere.

28. Some witnesses have suggested that one of the principal causes of the deterioration of the rivers has been the construction of weirs across them, and that considerable improvement might be achieved by the removal of these works. This is a theory which has, in our view, no foundation in fact. A weir may affect the regime of a river for some distance above it, but it cannot alter conditions below except immediately in its vicinity. It is quite incorrect to suppose that, in a case of this sort, where the weirs are situated at the head of the delta, they can have any influence in determining conditions lower down the river, except in so far as they serve to distribute the water between the branches, and there is no ground for believing that their removal would in any way ameliorate such conditions.

29 Lastly, we would refer to a proposal, put forward so long ago as the fifties of the last century and again raised in evidence before us, for disposing of the surplus water of the Mahanadi by discharging it, through an artificial cut in the dividing ridge, into the Monaguni river and thence into the Chilka Lake. It is impossible to predict the exact effect of such a scheme, but its execution would, in our view, invite a catastrophe. It would entail the diversion of a volume of water of the order of 750,000 cubic feet a second through an artificial channel with a slope of 100 feet in 15 miles, which would generate a velocity of at least 15 feet a second, into the Chilka Lake. To prevent the whole of the Mahanadi discharges from passing this way, a huge regulator would have to be built at the head of this channel, of which the cost would be very great. The channel itself would be half a mile wide and would have to be excavated through a hill 100 feet high. In its lower reaches it would have to be heavily embanked on both sides and would carry with it a continual threat of devastation by breaching. Finally, it would throw this enormous volume of water into a lake, the inadequate discharging capacity of which is one of the prime causes of floods in the Puri district and the high water level of which even now impedes the free flow of the waters of the southern branches of the Mahanadi. It has been calculated that, if the diversion were made, and unless the Chilka mouth opened so as to discharge the volume pouring in, which we regard as most problematical, the level of the lake would rise to an extent which might reach seven or eight feet for each day that a high flood lasted ; the consequential backing up of the water of the other rivers and the appalling inundation which would ensue make this proposed remedy far worse than the disease which it is designed to cure.

CHAPTER IV.

General summary of conclusions.

30. Before we come to deal with the individual rivers of Orissa we think that it will be well for us to state the general conclusions at which we have arrived as the result of our deliberations. The further chapters will then describe specific cases, show, with reference to such cases, the grounds on which our conclusions are based, and offer suggestions regarding problems arising on each river which are local rather than general.

31. The arable area of Orissa may be divided broadly into three portions:—

(a) The area protected from floods by embankments and irrigated by canals. We shall refer to this as the fully protected area.

(b) The area protected, to a greater or less degree, from floods by embankments but not irrigated by canals. We shall refer to this as the semi-protected area.

(c) The area which is neither protected from floods by embankments nor irrigated by canals. We shall refer to this as the unprotected area.

32. Dealing first with the fully protected area, we do not consider it necessary to repeat in detail the history of the introduction of canal irrigation into Orissa. It will suffice to say that, as the result of a report by Sir Arthur Cotton which has since been shown to have been based upon incorrect premises, the Orissa Canals were taken in hand in 1863 by a private company, the East India Irrigation and Canal Company, in spite of a warning from Government that the profits anticipated were almost certainly over-estimated. The Company failed in 1868, when the works were only half completed, and Government took them over and finished them, although on a less ambitious scale than had originally been contemplated. Owing to the huge capital cost the canal system has never been remunerative; it does little more than pay its working expenses, leaving the bulk of the interest on the original expenditure to be met from other sources. Since 1891, the cost of all new works required for the system has been met from revenue.

33. Owing to the deltaic nature of Orissa, already described, the highest land is along the banks of the main rivers and it is on these banks that the most important canals are situated, throwing out distributaries into the lower areas between them. The bank of the canal on the river side is maintained of great strength and at a high level, to serve as a flood bank, thus protecting the irrigated land. In this way three fully protected areas have come into being, namely, that irrigated by the Jajpur Canals, between the Baitarani and the Kharsua, that irrigated by the Pattamondai and Kendrapara Canals, between the Birupa on the north and the Mahanadi and Nuna on the south, and that irrigated by the Taldanda and Machgaon Canals between the Pyka and Mahanadi on the north and the Katjuri and Olanka on the south. These fully protected areas are the most prosperous portions of Orissa and it is in them that land values are highest.

34. Coming now to the semi-protected area, we find a great diversity of conditions. There are tracts which enjoy almost complete protection behind high and strong embankments, which breach only in the very highest floods. There are others, the protection afforded to which is so uncertain that any flood above the normal is apt to spell disaster. Finally, there are those, the destruction of whose defences is of almost annual occurrence. The condition of the people in these areas varies accordingly.

35. In the unprotected area no attempt is made to ward off the floods, and practically the whole of this area is annually submerged.

36. After two tours throughout the areas in question, one of which was undertaken during the flood season, after consideration of the records of past years and of previous investigations which have been placed before

us, and after collecting a large amount of new data on our own account, we have come to the conclusion that the problem which has arisen in Orissa is due in the main, to the efforts which have been made towards its protection. Every square mile of country from which spill water is excluded means the intensification of floods elsewhere; every embankment means the heading up of water on someone else's land. Orissa is a deltaic country and in such a country floods are inevitable; they are Nature's method of creating new land and it is useless to attempt to thwart her in her working. The problem in Orissa is not how to prevent floods, but how to pass them as quickly as possible to the sea. And the solution lies in removing all obstacles which militate against this result. Unfortunately, the fact that the delta is inhabited prevents this policy from being pursued in its entirety; the most that can be done is to follow it steadfastly in so far as it is compatible with the maintenance of the population. To continue as at present is merely to pile up a debt which will have to be paid, in distress and calamity, at the end.

37. That the embankment system is at the bottom of their troubles is, we have found, fully realized by the people of Orissa, and one of the most insistent demands made to us by the inhabitants of the semi-protected and unprotected areas is for the complete abolition of the canal systems and the throwing open of the fully protected area to the spill of the rivers. They argue that the effect of this protection is to intensify the floods on the remainder of the country and, as we have stated, there is clear justification for this view. But the remedy proposed is so drastic that we are unable to support it. Orissa is haunted by two spectres, flood and drought, and of these the latter is the more terrible. Great distress is caused by inundation but long-protracted drought is almost invariably followed by famine. It is possible to combat the effects of floods locally by the late transplantation of paddy and, in many parts, by the growing of *rabi* crops and of *dalua* paddy, sown in the winter months, but against the effects of drought there is no remedy except the importation of grain. The great famine of 1866, in which it is estimated that nearly 40 per cent. of the population of the Puri district perished, was due far more to the drought of 1865 than to the floods of the following year. While, with the improvement of communications, the recurrence of such a famine may be regarded as impossible, there is not the slightest doubt that, but for the existence of the fully protected area, the threat of scarcity would loom much larger in Orissa than it does at present. A large area of this nature, certain of its crops no matter what the seasonal conditions and producing a large surplus beyond its own immediate needs, provides an insurance against calamity to the country as a whole which is of inestimable value and which is not, we consider, too dearly purchased even at the price of greater flooding over the remaining areas. We do not shut our eyes to the fact that the time will come when, as the irrigated and protected land falls below the level of that open to free spill, the canals will have to go, but this time is not yet. We trust that, by then, conditions in the unirrigated areas will have improved sufficiently to render the insurance afforded by the irrigation systems no longer necessary.

38. We think further that there is a tendency to exaggerate the probable effect of the abolition of the canals. Many of the witnesses who gave evidence before us obviously considered that here, and here alone, lay the solution of the problem, and that, with such abolition, prosperity would be assured to all Orissa. We cannot, in this connection, do better than quote the opening paragraph of a report in respect of the inundations by the Mahanadi river and its branches and the measures calculated to ensure relief therefrom by Captain J. C. Harris of the Royal Engineers, written in 1858 before the Orissa Canals had been commenced:—

> "How great have been the vicissitudes to which the province of Orissa has been subjected; how vast the amount of suffering and how loud the lamentations of its inhabitants; how widely proclaimed, and deeply recognized, are the necessities of the district; how much might have been, and how little has been done towards the relief thereof will appear in the sequel, but I would ask, why are these things so in A.D. 1858?"

This scarcely sounds like a picture of halcyon days such as we are asked to believe existed before the introduction of the canals.

39. It is, therefore, in the semi-protected areas that, in our view, action towards the clearance of obstructions should, in the first instance, be taken. The whole system of embankments in these areas seems to have grown up without any reasoned plan underlying it. Some of the embankments have been constructed and are maintained by Government, some by the zamindars. There are marginal embankments, running along the banks of the rivers, and ring *bandhs*, completely enclosing villages and estates. They have come into being solely in the interests of the particular area to be protected, and with complete disregard (we think, indeed, that we may fairly say in most instances in complete ignorance) of their effects upon other areas. The river, shackled in one direction, bursts its bonds elsewhere; fresh shackles are applied at the new danger point which necessitate the strengthening of the original defences and the institution of new ones which would otherwise not have been required. The whole arrangement can only be described as chaotic.

40. There is not, to the best of our knowledge, a single embankment in the semi-protected area which can be regarded as really safe in a year of high flood and the position becomes more difficult year by year; in many cases matters have gone so far that efficient maintenance is no longer possible. There has been nothing in our tour which has struck us as more pitiable than the position of the people sheltering behind some of these illusory defences. The inevitable has happened; the closing off of the spill water of the river has resulted in their land becoming far lower than that outside, the construction of similar defences by their neighbours has still further raised the levels of the floods, they have been forced to raise their embankments until. a point has been reached when they can no longer be maintained, and they are subjected to calamities far greater than they would have experienced had they never enjoyed protection at all. Their prayer is all for higher and stronger embankments, not realizing that therein lies no salvation but only a further lowering of the relative level of their land and a short postponement of the ultimate day of retribution.

41. The time has come when this state of affairs should no longer be permitted to continue and systematic action should be taken to clear away all obstacles which obstruct the free flow-off of the water. The adoption of this policy will, of course, mean larger areas inundated, but, and this is the important point, the inundations will be shallower and will last for shorter periods. Inundation is inevitable, but, in itself, it is little more than an inconvenience; it is when the depth of inundation is excessive and its period prolonged that catastrophe occurs. *Saradh* paddy, the rice crop which is sown in June and harvested in December, will live for some fifteen days under water with very little damage; it is when, as at present, it is submerged for a month or more that the whole crop is lost.

42. While we believe that much of the land affected will not suffer seriously from the change, we realize that, in other parts, an alteration in the system of cropping will be essential. There are two prominent characteristics of the cultivator in the semi-protected area, namely, firstly, his trust in the strength of his defences, no matter how often it may be betrayed, and, secondly, the fact that he is wedded to *saradh* paddy. There seems to us to be considerable ground for a statement which was made before us that he would sooner raise a four-anna crop of *saradh* than a sixteen-anna crop of any other grain, and we have ourselves seen areas in which *saradh* paddy is sown annually although the cultivators admitted that, on account of flooding they had raised but one crop in ten years. If the *saradh* fails they have nothing to fall back upon but such few seedlings as they can obtain from outside.

43. We may contrast this state of affairs with that which obtains in the unprotected area. Here the cultivator accepts the floods as inevitable and orders his life accordingly. He does not broadcast his paddy, as is the general custom in the semi-protected areas, but waits till the worst of

the floods is over and then transplants, the transplantation extending some times even into early October; in this way he usually obtains some crop. Moreover, if conditions are in any way favourable, he will grow *dalua* paddy (the rice crop which is sown in December and harvested in May) and *rabi* pulses during the winter months. Members of the family go to Calcutta and elsewhere to find work, remitting money home and reducing the resident population; larger holdings are the result and, in general, the people in the unprotected area are not so badly off as might at first be imagined.

44. While there is, of course, no question of reducing the whole of the semi-protected area to the present condition of the unprotected (as we have said, we believe that much of the land affected will not suffer in any way while the unprotected area will greatly benefit) there are certain low-lying tracts, now classed as semi-protected, which will have to adopt the system of living prevalent in the unprotected parts. But these tracts are, in existing circumstances, so stricken that they could not possibly be worse off than they are; a change to unprotected conditions and the necessity for accepting those conditions and living accordingly will spell betterment rather than deterioration.

45. It is particularly, although not exclusively, in tracts such as these that we see a great field for activity on the part of the Agricultural Department. One of the troubles of Orissa is that, after the cessation of the monsoon, the whole country dries up. Neither *dalua* paddy nor *rabi* crops can be grown upon it without artificial irrigation and, in most parts, no means of irrigation are available. We believe that nothing would improve conditions more than acceptance of a winter crop as an important factor in the economic life of the country. It has been stated to us that only the lowest depressions are suitable for the growing of *dalua* paddy, and only the river margins for the cultivation of *rabi*, but we are by no means convinced that this view is correct; it is, we think, based too much on existing conditions under which only the depressions retain sufficient moisture during the winter to admit of *dalua* being grown, and only the river margins obtain the benefit of the deposition of silt. Were the spill of the rivers permitted to flow freely over the country we believe that a far greater area would be found suitable for *rabi*, while we see no reason why the higher lands should not be suitable for *dalua*, provided that an ample supply of water to mature it is assured. Such water is available in plenty in the rivers; the difficulty is to raise it on to the land and it is here that the assistance of the Agricultural Department will be required. We are of opinion that much could be done by the introduction of a system of raising water by pumping. Small temporary installations, such as can easily be installed after one year's floods and removed before those of the next, will be required in considerable numbers; possibly installations mounted on barges, which can be readily moved from place to place, would best answer the purpose. The cost of such installations would not, we think, be prohibitive, having in view the object to be attained; even if some loss on them is incurred, the money will be better spent than in remissions or relief. We consider that extensive experiments in this direction should be undertaken immediately.

46. We do not, of course, intend to suggest that every embankment in Orissa should be levelled, still less that they should be levelled simultaneously. The process will have to be gradual, commencing from the sea, and the case of each embankment will have to be considered on its merits. Some will certainly have to be altogether demolished but there are probably some which may be retained and still more which can be rendered innocuous by reducing their capacity for obstruction by the provision of escapes in them. Every embankment marked for permanent retention must, however, conform to two requirements, it must offer no obstruction to floods in excess of certain dimensions to be determined in each case, and it must be absolutely secure from breaching even in an exceptional flood. A breach is almost invariably a catastrophe; the water rushing through scours away the bank far below ground, usually carrying with it

large quantities of unfertile sand, and tears, in an uncontrolled torrent, through fields and homesteads. It is impossible to repair such a breach until the water has fallen much below the ordinary carrying capacity of the river, so that inundation from breaches is usually prolonged. Where an embankment is to be permanently maintained, some arrangement must be made for the passage of floods over it, without breaching, and this can be done by the provision of escapes, the top of the embankment being maintained, in general, above highest flood level but being lowered in certain lengths, these lengths being provided with masonry side walls and heavily pitched with stone, so as to prevent scour. Such escapes should be as long as possible so that the water flows over them without undue heading. In this way the force of the spill is reduced and its effect minimized, since the escape will naturally be placed at the spot where, when spill commences and there is a clear overfall, such spill will do least harm.

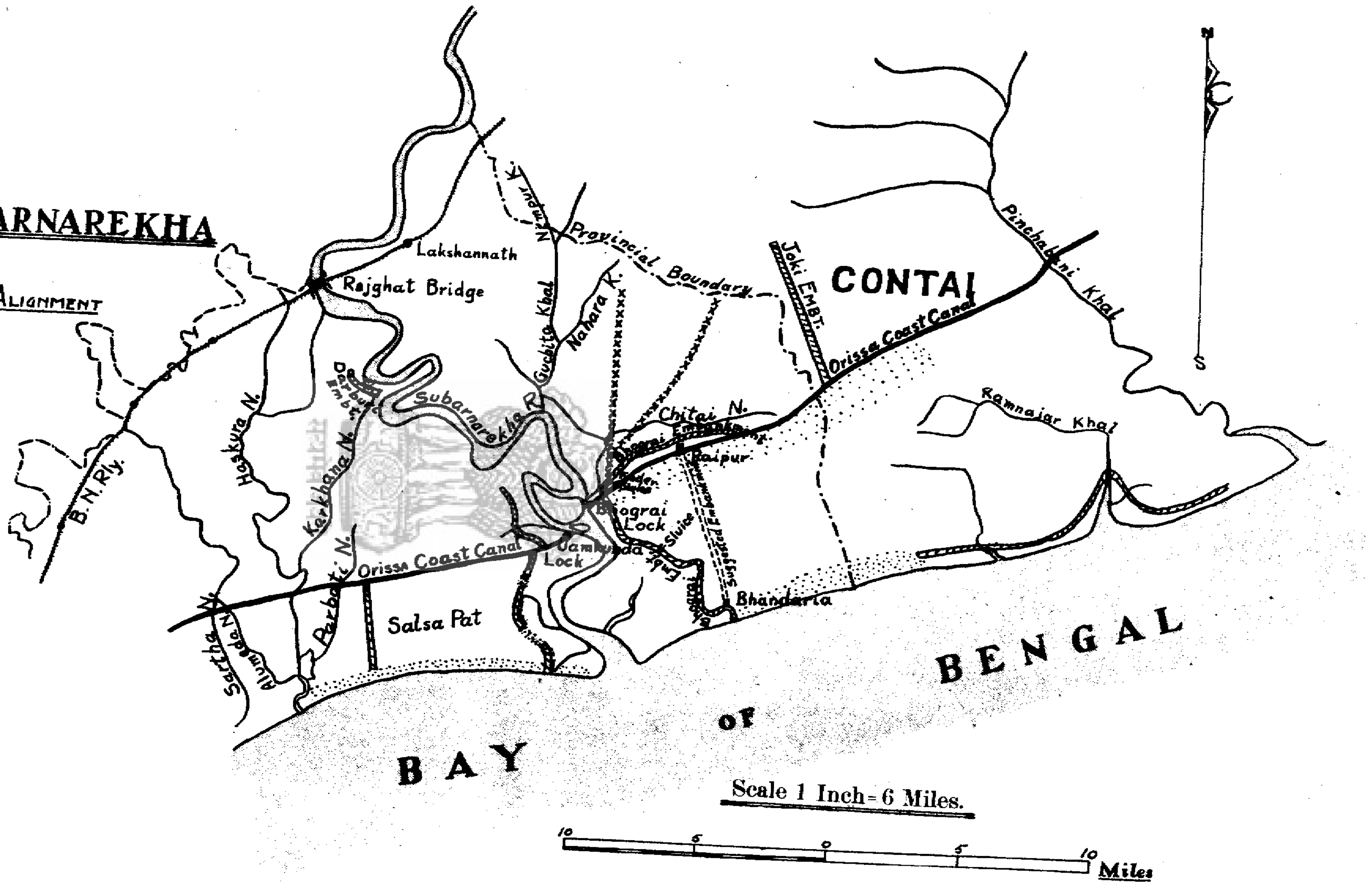
47. Complaints have been made, regarding certain of the escapes already existing, that they bring large quantities of sand into the fields. We are, however, inclined to doubt whether this is inevitable. Experiments on models show that, even in a river carrying heavy sand, practically clear water can be obtained at certain points, and indicate that the most favourable point in this respect is some two-thirds of the way round the concave side of a bend. A detailed and critical examination of the sand carrying capacity of past and existing breaches, and the construction of small experimental escapes to the same end, will, we have reason to think, make it possible to determine sites for escapes at which sand-spill will be reduced to a minimum.

48. More will, however, be required than the abolition of protective embankments if all obstruction to the free flow of flood water is to be removed. We shall, in dealing with the various rivers, advocate the opening up of certain old spill channels which were closed at the time of the construction of the canals. Another question, which demands a more detailed examination than we have been able to give, is the obstruction afforded by district board roads within the flooded area; many of these will, we are inclined to think, require remodelling on the lines we have suggested, in Chapter VIII, for the communications to and in the area served by the Orissa Coast Canal. Yet another question is that of the reclamation of land within the tidal basins of the various estuaries. The maintenance of these estuaries depends upon keeping the area over which the tide spills entirely free from all obstruction; this area forms a reservoir which is filled at each tide and it is the water rushing from this reservoir as the tide falls that keeps the estuary free of silt. If reclamation is permitted within the basin the area of the reservoir is diminished and the outgoing tide loses its force until, eventually, it amounts to a mere powerless rise and fall and the estuary dies. We have, during our tour, seen many examples of such reclamation and more is in progress; this is an activity which, in our view, should be immediately and absolutely suppressed.

49. The removal of obstructions to the workings of nature, whether in the form of floods or tides, is, we believe, the only cure for the troubles to which Orissa is now subject. If a policy to this end is pursued, except in so far as it must be relaxed to ensure the maintenance of the population, steadfastly and, if needs be, ruthlessly, we are convinced that much of the distress which at present exists can be removed and stable conditions ensured throughout the country.

MAP
OF THE
MOUTH OF THE SUBARNAREKHA

xxxx APPROXIMATE ALTERNATIVE ALIGNMENT OF EMBANKMENT PROPOSED



CHAPTER V.

The Subarnarekha.

50. As we have already mentioned in paragraph 13, the problem of mitigating the effects of the floods in the Subarnarekha is a local one and forms no part of the main flood problem of Orissa. It is, nevertheless, a matter of considerable importance and one which affects materially the province of Bengal as well as that of Orissa; it has, therefore, been specifically referred to us for advice.

51. The present position will be clear from a glance at the accompanying sketch map. An embankment, known as the Bhograi embankment, protects a considerable area situated on the left bank of the lowest reach of the Subarnarekha from the floods in that river. The northern portion of this embankment ties into the north bank of the Orissa Coast Canal which, a few miles further on, meets the Joki embankment, running north and south, this latter embankment being designed to prevent the spill of the Subarnarekha from passing eastwards into the Contai subdivision of the Midnapur District of Bengal.

52. The Bhograi and Coast Canal embankments and the Joki embankment thus meet almost at right angles and it is precisely in this angle that the lowest land in the vicinity is situated. When the Subarnarekha rises in flood, the water rushes into this depression, filling it to a depth of ten feet or more. The usual consequence is that the villagers, in an attempt to save their homes and crops, illegally, but not altogether unnaturally, cut the Bhograi embankment and thus allow the water to drain off, partly into the protected area and partly to the east into Bengal. In 1927, practically the whole of the protected area and 300 square miles of the Contai subdivision were flooded from this cause.

53. There are five distinct groups of people who are or may be affected by the floods of the Subarnarekha, namely,

(*a*) the people of Contai;

(*b*) the people living in the angle between the Bhograi and Joki embankments;

(*c*) the people living in the area protected by the Bhograi embankment;

(*d*) the people living in the so-called Salsa Pat, an area of some ten square miles on the right bank of the Subarnarekha bounded on the east by that river, on the north by the Coast Canal, and on the west by the group of streams comprising the Parbati, Karkhana, Haskura, Alumeda, and Sartha rivers, all of which, in flood time, carry spill water from the Subarnarekha. This group will, for brevity, be termed the Haskura group;

(*e*) the people living on the Haskura group of streams.

We took the precaution of hearing the views of the people of each of these tracts separately.

54. The people of Contai are interested solely in the efficient maintenance of the Bhograi and Joki embankments. Except when the former is breached, whether by accident or on purpose, they do not suffer from flooding from the Orissa side.

55. The people living in the angle between the Bhograi and Joki embankments produced, through a non-official committee specially convened to examine the question, a reasoned statement of the causes of their trouble and of the measures necessary for their relief. The courses which this committee advocated were the removal of the Bhograi lock of the Orissa Coast Canal some 3 or 4 miles eastward towards Raipur, so as to enlarge the

width between the Bhograi and Jamkunda locks and therewith the waterway of the Subarnarekha, the abolition of the curved portion of the Bhograi embankment south of the canal from near Raipur to Bhandaria, and the construction of embankments direct from above Raipur to Bhandaria, linking up the sandhills which lie between these places. They further advocated the maintenance of the mouth of the river as a strictly prohibited area with a view to preventing the construction of embankments for the protection of cultivation on areas reclaimed upon the islands and banks.

56. The committee in their statement enumerated and rejected, for reasons which we regard as adequate, a number of other proposals which had been put forward. These included the construction of a large embanked canal through Raipur to Bhandaria to drain the area in question, the widening and deepening of the various natural interior drainages of the flooded tract, such as the Nimpur, Nahara, Chitai and Guchita khals, the construction of an embanked canal from the southern end of the Joki embankment to the Ramnagar khal, the construction of a sluice in the Joki embankment with a view to flood water being passed out *via* the Coast Canal and the Pichabani khal, the construction of a marginal embankment on the left bank of the Subarnarekha, and an increase in the number of openings in the railway between Lakshannath Road and Rajghat.

57. A further suggestion, which was put before us in evidence, but was not included in the committee's statement, was that the Darburi embankment, which cuts off the head of the Haskura group of rivers from the Subarnarekha, should be abandoned, and the Subarnarekha trained to find a new outlet to the sea *via* this group.

58. The people living within the area protected by the Bhograi embankment objected strongly to the construction of the proposed Raipur-Bhandaria embankment. The removal of the portion of the Bhograi embankment to the west of this line would, they pointed out, throw at least twenty-five villages open to the ravages of flood, villages of far greater value than those which the scheme was designed to benefit. Moreover, they doubted whether any such benefit would actually be obtained; even were the Bhograi embankment removed, the sandhills on the sea-shore would still effectively prevent the free flow-off of the floods, and divert them through the same narrow mouth through which they pass at present.

59. The inhabitants of the Salsa Pat are not directly affected by any of the proposals. They are fairly well protected by marginal *bandhs* to the east and west, but they complained that considerable volumes of water were thrown on to their lands, partly from a Government drain in the vicinity of the Jamkunda lock which is leased out for fishing and the flow in which is obstructed by the lessees for that purpose, and partly from the Haskura group of rivers, owing to the construction of protective embankments along, and sometimes even across, their mouths by the zamindars. Even were the Darburi embankment abandoned and the Subarnarekha diverted into the Haskura group of rivers they did not think that, provided these protective embankments were removed, they would be adversely affected. Their particular trouble was the drainage of their area; after a flood in the Subarnarekha the water rose to a depth of 4 or 5 feet on their fields and for this water there was no escape. They had, by means of local co-operation, excavated a drainage channel through the sandhills on the east of their area, but, in the absence of a sluice, the channel had proved useless and, indeed, frequently had to be blocked up to prevent its serving as a means of ingress for floods. The construction of a sluice, which would open only in one direction and thus, while keeping out floods and salt water, would permit drainage water to escape, would, they considered, solve their difficulties.

60. The people living on the Haskura group of rivers echoed the complaint already mentioned regarding the embankments at their mouths; these embankments had been in existence for some thirteen years, they were from 6 to 8 feet high, and, in some cases, had been raised during the present year. Two of them were particularly harmful as they crossed, and completely blocked, the Karkhana and Alumeda rivers. They had the

strongest possible objection to the abandonment of the Darburi embankment, which would spell ruin to their homes; any breach in it, such as sometimes occurred, meant loss of houses and crops. Their desire was rather to see it lengthened and strengthened. Provided that this embankment held, the spill of the Subarnarekha did them more good than harm, except where it was held up by the Orissa Coast Canal, to prevent which they asked that the openings in the canal, which are of the nature of level crossings, should be both widened and increased in number.

61. As will be seen, the majority of the suggestions put forward, while designed to alleviate the troubles of one section of the people, could only be accepted at the sacrifice of another, and for this reason we find ourselves unable to concur in any of the more drastic proposals made. In our view the main trouble lies in the alignment of the existing Bhograi and Joki embankments, which is radically defective. Two embankments meeting at right angles with a low-lying pocket of land between them, one of which embankments lies across the direct line of the spill of the river, is an indefensible arrangement.

62. We are unwilling, as a general rule, to advocate the construction of new embankments but in this particular case we see no alternative. In the absence of full information as to the extent of the spill we are unable to lay down the exact alignment for this new embankment, but we show roughly two alternative alignments on the sketch map. The more easterly line is certainly feasible; it follows a well-defined ridge and an embankment upon it would be of only moderate height. But, provided that the land to the north is sufficiently high to enable an embankment to be tied into it without fear of its being outflanked, we consider that the guide bank on the alternative line to the west will be preferable; such an embankment would be higher but it would protect a very much greater area of land. With the construction of this new embankment, the portion of the existing Bhograi embankment north of the canal and the Joki embankment can be abandoned.

63. The drainage of the area protected by the new embankment will be effected by the Chitai nala, which should be cleared and for the passage of which a sluice should be provided in the embankment, and by a sluice to be built in the north bank of the Coast Canal near the 59th mile stone, just west of its present junction with the Joki embankment. This sluice will enable rain water to be drained into the canal and discharged by it to the east. Should the alignment of the embankment cut any of the other interior drainage lines of the tract, it will be for decision whether such drainage should be given a separate sluice or should be diverted into the Chitai. Sluices should also be provided for the irrigation of the area protected.

64. As regards the proposal to remove the Bhograi lock to the east so as to increase the waterway of the Subarnarekha, we are convinced that no such action is necessary. The distance between the Bhograi and Jamkunda locks is between two and three miles, which is ample to allow the water to pass freely if the space is retained unobstructed.

65. As regards the objections raised to the protective embankments in the beds of the Subarnarekha and of the rivers of the Haskura group, we cannot too strongly advocate the obtaining of control over such embankments, special legislation being undertaken for the purpose, if necessary. We deal with this subject more fully, in its general aspect, elsewhere in our report; it will suffice here merely to record our view that, without specific authorization from the Superintendent of Embankments, no embankment should be constructed by any private person in Orissa of a height greater than a height to be prescribed by the Superintendent, usually from one to two feet, this height being fixed as that necessary to exclude salt water but not to exclude floods. Suitable provision should also be made to secure the removal of any embankment which impedes the natural flow of flood water. If the maps which have been put before us in evidence are correct, certain of the embankments on the Haskura group of rivers are especially objectionable, as completely damming at least two of them; these embankments are situated in an estate under the management of the Court of Wards, and we trust

that Government will find it possible to take immediate action for their removal. For the remainder, both those on the Subarnarekha and those on the Haskura group, a detailed survey should be made showing the location and height of each, and orders passed thereon regarding their retention, lowering or removal.

66. Coming now to the position in the Salsa Pat, we agree as to the desirability of the sluice for which the inhabitants ask. We understand that it is usual, in such cases, for Government and the cultivators to share the cost between them; if this arrangement is decided upon we think that it would be only fair to value the work done by the cultivators upon the drain already excavated by them and to take this amount into consideration in assessing their share of the combined work. The sluice would be of no use without the drain, and we should be sorry to see the cultivators of the tract reap no benefit from their laudable example of co-operation.

67. We have referred, in regard to this tract, to the leasing out of a Government drain for fishing purposes. We consider that it should be impressed upon officers that leasing of this nature is most undesirable and that the small amount of revenue thereby obtainable is negligible when compared with the importance of keeping drainage lines intact.

68. Lastly, as regards the cultivators living on the Haskura group of rivers, their complaint as to the heading up of water by the Coast Canal will be removed if our recommendation that this Range of the canal be abandoned be accepted. We consider further that, in their interests, the Darburi embankment should be efficiently maintained.

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CHAPTER VI.

The area between the Subarnarekha and the Baitarani.

69 We have described, in the preceding chapter, the measures which we propose for the disposal of the floods of the Subarnarekha. We shall now deal briefly with the area which lies between that river and the Baitarani, reserving, however, for separate chapters, our recommendations regarding the arrangements necessary at the head of the Baitarani delta and the future of the Orissa Coast Canal.

70. The main rivers which traverse the tract are the Panchpara, the Burabalong, the Kansbans, the Gumai, and the Salindi, a tributary of the Baitarani. Of these, the Panchpara and Burabalong do but little damage, and no particular measures are required upon them beyond the control of the construction of *chak bandhs* at their mouths. There is flooding from both the Kansbans and the Gumai, and this we believe to be due, to a considerable extent, to the unsatisfactory condition of their estuaries. The efficiency of these estuaries has been destroyed by the crossings of the Coast Canal, consisting of in-and-out sluices of quite inadequate capacity in the case of the Kansbans, and of a level crossing in that of the Gumai. If, as we recommend in our chapter regarding the Coast Canal, this Range of the canal is abandoned, the crossings are dismantled, the Bhadrak-Chandbali road is lowered, sluices are provided in the salt embankment and, possibly, an embankment is constructed on the right bank of the Gumai to clear that estuary, we believe that a considerable amelioration of conditions can be achieved in the area under consideration.

71. This area was seriously affected by the great flood of the Baitarani in 1927, which, after breaching the left embankment of the river both above and below the Bengal-Nagpur Railway, destroyed a considerable portion of the latter and rushed across and down the country towards Bhadrak and Dhamnagar. We deal, in the next chapter, with the arrangements necessary for disposing of another flood of this magnitude; it will suffice here to say that we believe that, by the provision of an escape in the left embankment and an increase in the openings given in the railway line, the effect of a cataclysm of this nature can be greatly mitigated. The volume of water which has to be disposed of over the country will then be limited to the peak of the flood; when this has passed, the escape will cease to operate. Moreover, the escape in question will never discharge a greater depth than three feet over its cill, with the result that the sudden and devastating inrush of water, which followed the breaching of the embankments in 1927, will be obviated.

72. We have given careful consideration to the question whether Range III of the High Level Canal, which runs from the Baitarani to Bhadrak, should continue to be maintained. It crosses, at right angles, the discharge line of the proposed escape in the Baitarani left embankment, and it is clear that, if Range II is abandoned as we suggest in the next chapter, the utility of Range III as a navigation work will be much reduced, as it will serve only for local traffic, the amount of which is very small. A considerable area of paddy is, however, irrigated from this canal, and we should be sorry to see this irrigation abandoned; it must, in this connection, be remembered that the Baitarani escape will not come into operation annually, but only in years of exceptional flood. We are, therefore, of opinion that Range III should be maintained, subject to the small modification proposed in the next paragraph, but the flood bank should be lowered in certain lengths and breaching sections provided. In this way, if an exceptional flood occurs, it will be possible to pass the water across the canal at selected points, where repairs can subsequently be effected at a minimum cost.

73. The modification to which reference is made above concerns the better protection against floods of the town of Bhadrak. When the Baita-

rani is in flood, water passes eastwards along the northern bank of the High Level Canal and debouches through the narrow gap between the terminus of the canal and the right embankment of the Salindi, this concentrated flow pouring into the Salindi, lower down, gorging that river, and seriously endangering the town. We anticipate that these conditions will, as a rule, cease to obtain owing to the construction of the escape in the Baitarani left embankment and the provision of breaching sections in the canal but, even so, the same effect may be experienced during a high flood, although in a less marked degree than at present. The situation could be improved by abandoning the present terminus of the canal and ending it at the bifurcation, thus increasing the width of the gap to about one and a half miles. We recommend that this be done, cuts being made through the abandoned portion of the canal so as to permit of the free passage of water. As already stated, the amount of navigation on this Range will, in future, be small, and, at the worst, merely a short additional cartage into the town is involved. The irrigation now effected by the single distributary which has its head in the portion proposed for abandonment can easily be linked to the new terminus. The adequacy of the waterway at present provided in the Orissa Trunk Road near Bhadrak will have to be examined in the light of this recommendation.

74. We now come to the question which, more than any other, appears to exercise the minds of the inhabitants of the Dhamnagar *thana*, namely, the opening of the Benga, Patpur, and Kianali. These nalas are effluents of the Baitarani, the Kianali having its head above the town of Jajpur, while the Benga and Patpur take off from the river below it; they formerly discharged water across the area irrigated by the Jajpur Canals, on the right bank of the Baitarani, but were closed by an embankment when those canals were constructed. The local Government decided some years ago that sluices should be provided for the Benga and Patpur, but effect has not yet been given to this decision; we consider that the work should now be taken in hand although we may say at once that we do not for a moment anticipate that it will have the marked effect which the people living on the other bank of the river appear to expect. The relief afforded cannot but be small but, from the sanitary point of view if from no other, it is unwise to leave these channels in their present stagnant condition. We cannot, of course, contemplate open cuts in the embankment and the diversion of an uncontrolled volume of water through the Jajpur area into the Kharsua; it is clear that, even before the canals were constructed, the channels never drew off any very great supply, as the Benga, at least, is shewn in the old maps as heavily embanked on both sides, which must have markedly restricted its discharge. Sluices should be constructed for both the Benga and Patpur in the Baitarani embankment, designed to carry the maximum volume of water of which the channels can dispose after they have been cleared and, if necessary, widened or deepened at places where the section is tight. Both the sluices and the arrangements for carrying the distributaries of the Jajpur Canals under the nalas should be so built that they can be enlarged at a minimum of expense in the event of the channels improving. We cannot recommend similar action as regards the Kianali. It has its head in a loop of the Baitarani in which no water flows except in high flood; it would, moreover, in any event, be inadvisable to open a channel in the narrow neck between this loop and the Burha. Expensive crossings for the Jajpur distributaries would be necessitated and, even then, no relief would be obtained. If any appreciable discharge were diverted into it, it would inevitably flood out the town of Jajpur. We recommend, however, that arrangements should be made to flush the Kianali with water from the Jajpur Canal.

75. It has been suggested that the Dhamnagar *thana* would be benefited by the excavation of drainage channels to lead flood water more directly into the Matai. We are not in a position to make a definite recommendation on this point but it is one which, in our view, merits further local investigation.

CHAPTER VII.

The head of the Baitarani delta.

76. Before discussing the arrangements which we propose at the head of the Baitarani delta, a brief description of its principal features may be of use. The river emerges from the hills in a single channel and, shortly after leaving the Feudatory States, is crossed by the Bengal-Nagpur Railway. Some six miles below the railway the river divides into two branches, the Burha on the right and the Baitarani on the left. Each of these is spanned by a masonry weir immediately below the bifurcation, the Burha weir to feed the Jajpur Canal, which has its head in the sharp angle between the two rivers, and the Baitarani weir to feed Range III of the High Level Canal.

77. In order to confine the river to its proper channel above the weirs, marginal embankments have been constructed on both banks. That on the right bank extends up to the railway; that on the left bank extends to a point twelve miles above the railway crossing.

78 We have examined the records of high floods since 1885 in an attempt to determine whether deltaic action is at present in progress at the head of the Baitarani delta, but have been unable to reach any satisfactory conclusion in the matter. It is true that, during the last five years the average high flood level has been higher than in the past, while the railway engineers report a rise of two feet in the level of the bed at their bridge, but this may possibly be due to increased congestion lower down. Without detailed and continuous observations such as, in Chapter XIII, we have recommended should be taken in future, it is impossible to determine accurately what is taking place.

79. Probably no one will ever be able to calculate the exact amount of water which passed down the Baitarani in the great flood of 1927. It breached the left embankment above the railway in numerous places, destroying about eleven miles of the railway itself, burst both embankments below the railway, and overtopped all the masonry works at the heads of the canals. In order to calculate the total volume of the flood it would be necessary to ascertain, firstly, the difference in water level between the two sides of each breach and, secondly, the exact sequence of events, specially whether the breaches took place before or after the maximum level was reached at the canal heads. Unfortunately, those on the spot were so busy saving their lives that they had no opportunity to make detailed hydraulic observations. The highest flood previously recorded was 250,000 cubic feet per second; this flood rose to the parapets of the masonry works at the canal heads and may be regarded as the maximum which the weirs can discharge. After consideration of all available information regarding the 1927 flood we do not think that it would be safe to put the volume discharged at a lower figure than 400,000 cubic feet per second.

80. The 1927 flood was, of course, quite exceptional; it was the result of eighteen inches of rain falling in two days upon an already saturated catchment, and coincided with the period of highest spring tides. Having occurred, however, it would, in our view, be imprudent not to provide for its recurrence. It is, therefore, necessary to arrange for the disposal of 150,000 cubic feet per second more than can be passed by the existing weirs.

81. The first question which arises is that of the maintenance of the long left embankment above the railway, the failure of which spells disaster not only to the main lines of communication of Orissa, the Orissa Trunk Road as well as the railway, but also to a large agricultural tract. We advise that the top of the embankment be raised throughout its length to a level three feet above that of the flood of 1927 and that an escape, 4,000 feet long, be constructed in it, with its crest six feet below the top of the embankment as raised. Should another such flood occur an escape of this

length would, during its peak, discharge about 70,000 cubic feet per second with a depth of three feet over its crest. This discharge would last for a short period only and we understand that the railway are prepared to provide the additional waterway necessary to pass it across the line; they are providing also more waterway on the right bank of the river. Further, we do not think that it would be unfair if the local Government asked the railway for a contribution towards the heavy cost of raising the embankment and constructing the escape, in view of the far greater security against flood damage which the latter will enjoy than they have ever enjoyed in the past.

82. At its upper end the embankment runs some two miles from the bank of the river, and it is necessary to provide for the drainage thus intercepted. There is a small breach about 9½ miles above the railway through which this drainage at present passes into the Rebo. This breach might be left open, being revetted to prevent its widening further.

83. Coming now to the embankments on both sides of the river below the railway, we recommend that these be similarly raised to a height three feet above that of the flood in 1927. In such a flood, 330,000 cubic feet per second will be passing under the railway bridge, so a further reduction of 80,000 cubic feet is necessary in order to bring the volume down to that which the weirs can carry. This should be effected by the provision of an escape, 3,000 feet long, in the right embankment, with its crest four feet below flood level, that is to say, seven feet below the top of the embankment as raised. There was a very large breach in the fifth mile in 1927, and the escape might be constructed a short distance above the breach; the actual site of the breach would be unsuitable for the purpose as the land there is very low and has been deeply scoured. We do not propose any escape in the left embankment below the railway as we are unwilling to send more water than is absolutely necessary towards Dhamnagar and Bhadrak.

84. With the introduction of these arrangements, we recommend that Range II of the High Level Canal be abandoned. If it were maintained it would be necessary, in order to ensure that the water coming from the escape in the right embankment of the river was not impeded in its passage into the Burha, to prescribe that the banks should be maintained not more than eighteen inches above irrigation level in the canal; the breaches caused by the flood of 1927 were, as an experimental measure, filled to this level, but they breached again in the first flood of the present year. Having in view the facts that the other end of the Range will also lie directly below an escape, the Ganda escape, the construction of which we advocate in Chapter IX, and that the amount of irrigation effected from the Range is inconsiderable, it is certain that the cost of its maintenance and repair would far exceed any amount which could be hoped for as revenue from it. Hence our recommendation that the Range be abandoned.

85. During our inspection in August we noticed that a considerable area of land was submerged between the breach in the right embankment and the High Level Canal. This water should be drained off by the excavation of a cannel leading either to the existing aqueduct under or to a cut to be made through the abandoned canal.

CHAPTER VIII.

The Orissa Coast Canal.

86. The Orissa Coast Canal runs parallel to and a few miles from the sea and, in conjunction with the Hijili Tidal Canal in Bengal, affords a navigable waterway between the Hooghly and the Dhamra. The complete system consists of six Ranges, of a total length of 131 miles. Ranges I and II, 11 and 17 miles long, respectively, connect the Hooghly with the Haldi and the Haldi with the Russulpur; these Ranges constitute the Hijili Tidal Canal. Ranges III, IVA, IVB and V, which are 35, 17, 6 and 37 miles long, respectively, connect the Russulpur with the Subarnarekha, the Subarnarekha with the Panchpara, the Panchpara with the Burabalong and, finally, the Burabalong with the Matai, a navigable channel which flows into the Dhamra below Chandbali. The Orissa Coast Canal enters Orissa from Bengal at the 27th mile of Range III.

87. The canal was first projected in 1877, and was opened in 1886. The main argument advanced in its favour was the complete isolation of the province of Orissa; there being no communication with Calcutta by either rail or river, the trade of the province was driven to take the sea route. The ports of Orissa were, however, rapidly deteriorating, with the result that transport by sea was attended with many difficulties and much expense. A railway into Orissa was held to be impossible owing to the enormous amount of drainage which it would have to cross, and, in such circumstances, the provision of an inland waterway was advanced as a necessity. It is interesting to notice that, in the project, great stress was laid upon the magnitude and importance of the passenger traffic which would, it was anticipated, be diverted from the sea route to the canal.

88. The project has never fulfilled the anticipations of its framers, although, for many years, it served a useful purpose, being the only means by which grain could be brought into Orissa in time of scarcity. With the advent of the Bengal-Nagpur Railway its period of usefulness came virtually to an end, and for long past navigation upon it has almost ceased, such as continues being confined to local traffic by country boats between the villages in its vicinity and, to a very limited amount, of export traffic between these villages and Balasore. The tollage collected at the various locks hardly pays for the establishment employed to collect it, leaving the annual charge for the upkeep of the canal to be otherwise met.

89. In such circumstances, there has naturally been disinclination to spend any large amount of money upon its maintenance and its deterioration has, consequently, been heavy. We have inspected the canal from the point where it enters Orissa to its terminus at Charbattia and have thus had a good opportunity to observe its state. All the gates, and in some cases the gearing also, of the seven locks in this portion are worn out to such an extent that repair is impossible and nothing but complete renewal will avail. In many stretches, the banks are no more than a series of mounds, through the gaps between which water flows in some cases from the canal into the fields, in others from the fields into the canal. In long reaches the channel is silted and fails to afford the depth of water required for navigation. The arrangements for passing drainage across it are quite inadequate; existing works require repair and enlargement, often on an extensive scale, and new works are also needed. We have not gone to the labour of making out a detailed estimate of the cost of putting the canal into reasonable order but we do not consider that it could be done for less than five or six lakhs of rupees, while the expenditure might be considerably more.

90. Were the Coast Canal not in existence, we have no hesitation in saying that no one would to-day propose a navigation canal between Orissa and Bengal, still less a canal on this alignment. But the Coast

Canal is there, the cost of its construction has been incurred, and the question which we have to face is whether or not it is desirable to maintain it.

91. After careful consideration of the question in all its bearings we are of opinion that Ranges IVA, IVB and V of the canal should be entirely abandoned, as the harm which it does is out of all proportion to any benefit which it confers. As we have already stated, the traffic upon it is negligible and enquiry among the villages educed no expression of any general desire for its retention. The popular feeling seemed to be that, viewed as a means of transport, it was already out of action for so large a portion of the year that it would make little difference were it abandoned altogether.

92. On the other hand, the harm which it does is undeniable. In a country such as Orissa where the capacity of the rivers is often only a fraction of the total volume of water to be disposed of, the excess water must necessarily pass to the sea over the surface of the land. In such circumstances, it is in the highest degree unwise deliberately to interpose a barrier 60 miles long between this water and the sea. The result can only be the formation of a reservoir upstream of the barrier, a reservoir which, owing to the flat slope of the country in the lower portion of the delta can, and does, attain huge dimensions. The provision of numerous and large cross drainage works might serve to mitigate this evil to some extent, but even this solution would be far inferior to permitting the water to flow freely, in an unbroken film, towards the sea, while its cost would be such as could not reasonably be contemplated in the present case.

93 We believe that the abandonment of this canal will materially improve conditions in the low-lying and, at present, badly flooded country which borders the salt tract in the Balasore district.

94. It has been suggested to us that, with the closing of the steamer service from Chandbali to Calcutta, which came to an end last spring the Coast Canal will assume a new importance. We do not consider, however, that the amount of traffic which was previously carried by one small steamer, running a bi-weekly service, would justify the expenditure of so large a sum of money as the renovation of the Coast Canal would entail and still less the subjection of the country in general to the disabilities which are inevitable if the canal is maintained. Stress has also been laid, by those who have advocated its retention, upon the value of the canal banks as a measure of defence against storm waves coming in from the Bay of Bengal. While there is some force in this argument, we cannot agree that it is a sound policy to maintain, as a defence against a calamity which may happen once in forty years, a structure which intensifies, for the country above it, a calamity which occurs almost annually.

95. It has been suggested that the establishment of a port at Dhamra would open a new era of prosperity for the Coast Canal. We had actually drafted a paragraph stating that, as the result of an examination of the chart of the estuary prepared in connection with that scheme, and a comparison of this chart with that of 1885, we were of opinion that it was impracticable, when we received the local Government's memorandum embodying the same conclusion. It is not, therefore, necessary for us to labour the point further. In any event, a port which depended upon a navigation canal, capable of accommodating boats only up to four feet draught, would be a complete anachronism and consequently we do not think that this objection to the abandonment of the canal need be seriously considered.

96. We are, however, strongly of opinion that, with the abandonment of the Coast Canal, the lateral communications which at present exist between the main through communications of Orissa, as represented by the Orissa Trunk Road and Bengal-Nagpur Railway, and the seaboard tract of Balasore, should be improved. The most important of these is the road from Bhadrak to Chandbali. This road is subject to damage by cross drainage throughout the last ten miles of its length, the flood water of the

Baitarani sweeping over this portion in its passage to the sea; in consequence it is almost invariably breached in numerous places and becomes impassable, except with great difficulty, not only during the rains but until late in the cold weather, when the necessary repairs have been effected. We realize that the provision of a road on this alignment which could be maintained intact and passable throughout the flood season and which would not seriously interfere with the drainage of the country would involve so great a length of major bridging as to be prohibitively expensive. But it would, we believe, be possible to construct, at a cost not disproportionate to the advantages to be gained, a road which, while impassable during the actual passage of floods, would be passable immediately they subsided. Such a road should be metalled throughout; in its upper portion it might well be embanked and properly bridged but, in its last ten miles, it should be maintained not more than a foot above ground level, drainages being crossed by vented causeways. Such a road would present little or no obstacle to the passage of floods; it would merely be submerged, becoming available again as soon as the flood had passed. For the service of the people living in the seaboard tract in the neighbourhood of the Subarnarekha the existing road from Basta to Baliapal should be similarly dealt with.

97. In addition to the improvement of the Bhadrak-Chandbali and Basta-Baliapal roads, we recommend the improvement and metalling of three existing feeder roads, from Nungulsur to the Basta-Baliapal road, from Basudebpur to Marcona, and from Charbattia to the Bhadrak-Chandbali road. With these communications maintained in good order, we consider that the needs of the people in the tract which will be most affected by the abandonment of the Coast Canal will be adequately served; the feeder roads which we have mentioned are comparatively short and will not present the same difficulty in maintenance as will the Bhadrak-Chandbali and Basta-Baliapal roads, as they cross no very marked drainages.

98. This road programme will, however, undoubtedly be expensive and, if left to the district board, will probably impose too heavy a drain upon its resources. We regard it as very important that the roads in question should be properly constructed in the first instance and properly maintained thereafter, and we think that, in view of the technical difficulties and of the expense involved, the local Government should seriously consider treating them as provincial roads.

99. During our inspection of the Coast Canal, complaints were made to us that the free flow of drainage is also obstructed by the salt embankment which runs along the coast, parallel to the Coast Canal and between it and the sea, for the purpose of keeping salt water from the arable land. We were unable, in the time at our disposal, to inspect more than a short length of this embankment, which is extremely inaccessible, but we are convinced that there are grounds for the complaint; the existence of obstruction is proved by the fact that, last year, the embankment was breached, from the land side, in more than sixty places. The question should be the subject of special and careful investigation by an officer who should be charged to report, firstly, whether the salt embankment is either in general or in any portion higher than its immediate object warrants and, secondly, to what extent the provision of tidal sluices is necessary, such sluices being designed to escape drainage while excluding salt water. The investigation should cover not only that portion of the salt embankment which is maintained by Government but also that portion built in continuation of the Government embankment, which has been constructed and is maintained by the Raja of Kanika. It will, further, almost certainly be necessary to extend the salt embankment so as to form a right flank embankment to the Gumai estuary with a view to preventing salt water from the estuary from flooding the low fields on this bank; at present the estuary is dying owing to the construction across it of the Coast Canal level crossing, but we hope that, with the demolition of that work, it will revive. In view of this possibility, we are unable to entertain the plea of

the villagers for a flood embankment on the right bank of the river; the improvement of the estuary and its conversion into an efficient flood carrier is the only really satisfactory solution of their difficulties. It may possibly be necessary later to construct such an embankment not primarily for protection but so as to force additional water down the estuary with a view to opening it, but we would give nature a chance of doing it in her own way first.

100. When the Coast Canal is abandoned, frequent cuts should be made in both banks and *bandhs* constructed across it at river crossings to prevent the ingress of salt water; the masonry works at all such crossings should be completely dismantled and leading cuts made in an attempt to induce the rivers to clear out the silt which, in course of time, has accumulated both in the canal at the crossings and in the estuaries below them. Thereafter, the land should, we think, be made over to the Collector for management as a Khas Mahal estate. We anticipate that it will not be long before the banks are ploughed in and the bed of the canal comes under cultivation. We do not consider that there is much danger of an increase of malaria owing to the existence of what will, inevitably, be a long low-lying strip of land, as, during the season when the mosquito is breeding, the strip will be continually flushed with silt-laden water.

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CHAPTER IX.

The head of the Brahmini delta.

101. The head of the Brahmini delta is, in many respects, very similar to that of the Baitarani. Like the latter river, the Brahmini emerges from the hills in a single channel, to be crossed by the railway about a mile above its first bifurcation, where it divides into two main streams, the Brahmini on the right and the Pattia (known lower down as the Kharsua) on the left. Each of these is spanned by a masonry weir, the Brahmini almost immediately and the Pattia a short distance below the bifurcation, the two weirs being connected by an embankment some 2½ miles long. The Dudhai Canal; which has its head in the angle between the two works, is fed by the Brahmini weir; the Pattia weir feeds Range II of the High Level Canal. The Brahmini weir consists of a solid wall of masonry, with sluices at either end; the Pattia weir, on the contrary, is more in the nature of a barrage, comprising a low floor and talus on which falling shutters, ten feet high, are fixed.

102. There is a guide bank on the right of the Brahmini, known as the Pingua Embankment, which extends for some 10½ miles above the weir. The left flank of the Pattia weir is tied into the neighbouring high ground by the Ganda embankment which, though only 1½ miles in length, is very high in the portion nearest the weir.

103. The Brahmini has lately shewn signs of considerable deterioration, to such an extent that the greater portion of the weir is now buried in sand and practically the whole supply of the river, except in flood, passes down the Pattia. We have examined the gauge records for the past fifty years in order to see whether this deterioration can be ascribed to normal deltaic action and, as a result, are of opinion that this is not the case; the change has not been a gradual one but occurred suddenly during the floods of 1920. Prior to that year the level of the highest floods, averaged over decennial periods, remained practically constant; since then it has been about eighteen inches higher. Before 1920 floods which exceeded the danger level, that is to say, the level above which there is danger of the river embankments breaching, occurred, on an average, in alternate years; since 1920 they have occurred in three years out of every four. Moreover, the three highest known floods have happened during and since 1920. From these conclusions it may safely be assumed, firstly, that the Brahmini has deteriorated, secondly, that the deterioration took place suddenly and not as the result of normal deltaic action and thirdly, that it took place in 1920. We think that there is little doubt that the flood of 1920 deposited a vast quantity of sand at the head of the delta, which no succeeding flood has had the strength to wash away. Consequently, the river has now a marked tendency to burst away to the left, a tendency which, unless checked, will probably result in the Kharsua being called upon to carry not only its own discharge, but a large proportion of that of the Brahmini as well. This tendency is evidenced by the marked improvement which has taken place in the Pattia and also by two further symptoms to which reference is made later in this chapter, namely, the breaching of the Ganda embankment and the opening up of the Janardan *ghai*.

104. It is significant that the deterioration at the head of the Brahmini delta took place at about the time when the Uttikan and Gajaria embankments, in the lower reaches of the river, were raised to their present height. It seems to us very probable that the raising of these embankments, and consequently of the flood level in their vicinity, has, by reducing the surface slope of the river, been a contributory cause of the deterioration higher up.

105. The threat of an avulsion of the Brahmini is a serious one, and steps should immediately be taken to avert it. The first such step should be the removal of the Brahmini weir. This weir has ceased to serve any useful purpose, since we propose below that the Dudhai Canal should be abandoned A cut was made in the weir a couple of years ago, but the site of the cut was

badly chosen and it was immediately choked with sand. We do not consider that a single cut is sufficient; the whole of the crest wall and the under sluice piers should be removed, and numerous cuts made through the body and talus of the weir and under sluices. We hope by the removal of the Aul and Gajaria embankments and the curtailment of the Uttikan embankment, measures which we advocate in the next chapter, to induce a draw in the Brahmini which should enable a heavy flood to clear its head, but this effect is unlikely to be attained so long as anything in the nature of a continuous barrier remains across it.

106. It has been suggested that, if a much greater discharge than at present is forced down the Brahmini, water will be backed up below Range I of the High Level Canal and block the drainage from the north passing across that canal through the Kuaria and Mattagunjar aqueducts. We do not, however, consider that this difficulty is a serious one or likely to give rise to more than temporary inconvenience during the height of a flood, provided that care is taken to keep the approach and outfall channels to and from the works clear of all obstructions, which is not the case at present.

107. At the same time measures should be taken to reduce the discharge which passes down the Pattia. At present the floor of this weir is 8½ feet below the masonry crest of the Brahmini weir and about 12 feet below the top of the sand which has accumulated upon the latter in most of its length. We recommend that the shutters should be removed from the Pattia weir and that, in their place, a solid body wall five feet high, with a crest width sufficient to admit of its being raised still further, should it later be found necessary to do so, should be erected on the existing floor, the materials salved from the demolition of the Brahmini weir being utilized for the purpose. It is hoped, by this means, to force the lower floods, in which the water is clearer and of which the sand scouring capacity is consequently greater, down the Brahmini instead of allowing them to pass down the Pattia. The Pattia weir will be useless for any purpose other than regulation between the branches of the river if, as recommended in Chapter VII, Range II of the High Level Canal be abandoned.

108. As already explained, the Pattia weir is tied into the high land on the left by the Ganda embankment. This embankment breached in 1920, 1926 and 1927; the breach was not repaired after the last-mentioned flood and there is considerable feeling among those living in the vicinity that it should remain open. This feeling is undoubtedly due to the fact that the Brahmini has also burst its left bank at the Janardan *ghai*, a mile below the weir, damaging a considerable area of cultivation by sand spill; the villagers hope that, by escaping a large volume of water into the Pattia through the Ganda breach, the pressure at Janardan will be relieved. Indeed, there was practically no opposition to this proposal, as the discharge channel from the breach, after crossing Range II of the High Level Canal, falls almost immediately into the Pattia, and all those affected by it have already moved their homes.

109. We consider, however, that it would be quite unsound to leave the breach open. In the first place, we wish to avoid drawing more water from the Brahmini into the Pattia than is absolutely necessary, as thereby the scouring capacity of the former will be reduced. In the second place, there is a very real danger, if the breach is left open, of an avulsion of the whole river to that side. Even if a complete avulsion did not take place, it is undesirable to throw a large additional volume into the Kharsua when, but for the recent deterioration, the Brahmini is quite capable of carrying it.

110. We recommend, therefore, that the embankment should be raised so that its top will be three feet above highest known flood level, where this is not already the case, and that an escape should be constructed in it 1,400 feet long with its cill eight feet below the top of the embankment; such an escape will discharge about 50,000 cubic feet per second at high flood level with five feet of water on its cill. This escape should not be built at the site of the present breach, where the embankment is highest, but further to the north;

from a study of the longitudinal section it would appear that a site can be found in this portion where part of the escape can be placed at ground level while no portion of the crest need be more than five feet above ground. It may be remarked that the breaches in the Ganda Embankment have invariably occurred without the embankment being topped; the portion breached should, therefore, when reconstructed, be suitably strengthened so as to make the recurrence of such an accident impossible.

111. It may possibly be thought that, in view of the recommendation which we have made regarding the removal of the Brahmini weir, we are erring on the side of caution in suggesting so large an escape in the Ganda Embankment. But we think that there is justification for our attitude. In the first place, the sand barrier at the head of the Brahmini is a very big one and will take time to scour away; until this has been effected the holding of the Ganda Embankment without adequate escape facilities would involve serious risk to the Pingua Embankment on the other side of the river. In the second place, we have been struck by the fact that the highest known flood in the Brahmini, computed as 650,000 cubic feet per second from a catchment area of 13,700 square miles, is almost exactly the same as the maximum known flood in the Damodar, derived from a catchment of 7,200 square miles only. We think it probable that, whereas the Mahanadi and Baitarani have, during the period covered by the records, experienced the phenomenal type of flood which occurs perhaps only once in a century (the Baitarani so lately as last year), such a flood is still to be experienced on the Brahmini. This consideration affords an additional justification for allowing a margin of safety in works on the latter river.

112. The dismantlement of the Brahmini weir and the remodelling of that across the Pattia will render the maintenance of an irrigation supply in the Dudhai Canal impossible and we recommend that this canal be abandoned. Even at present it serves little useful purpose. It did not form part of the original Orissa Canal system, but was constructed at a later date; it is not protected by embankments and, consequently, it is liable to complete submergence whenever there is a flood in the Brahmini. Breached banks and the entry of large quantities of sand and silt, are the inevitable results. The direct irrigation effected from it is very small; the main function which it serves is to carry water for the irrigation of *dalua* paddy in the vicinity of Aül. But, even for this purpose, it is extremely inefficient. The Kani Nadi, into which the water has to be discharged, is situated 40 miles below the head of the canal, part of which runs through very sandy soil, with the result that there is excessive percolation and that only a small percentage of water entering the head ever reaches the tail. It has then to be passed into the Kani Nadi in which the villagers erect sand *bandhs* in order to divert it to the area to be irrigated; by the time that area is reached the supply is so minute as to be virtually useless. We do not consider that, in such circumstances, the canal is worth maintaining; the proper method of irrigating *dalua* paddy in Aul is not by attaching it to the tail of an entirely unsatisfactory and untrustworthy canal forty miles long but by pumping water on to the land from the adjacent rivers.

113. We now come to the question of the Janardan *ghai*, to which we have already referred. This *ghai*, or breach, is situated about a mile below the Brahmini weir on the left bank of the river; it is stated to have had its origin in a watercourse dug by one Janardan, many decades ago. The *ghai* is crossed by a detached zamindari embankment in which a paved escape was constructed by Government in 1903 at the cost of the zamindars, Government undertaking its maintenance. The escape was outflanked in 1926, and was repaired after the floods of that year; the floods of 1927 overflanked it again, and three further breaches occurred in the embankment lower down, known, respectively, as the Manika, Sahara, and Bisai *ghais*. These breaches have all remained open since the 1927 flood and the question has arisen whether, and if so how, they should be repaired. There have been serious and justifiable complaints regarding the large amount of sand which is washed through these breaches and has rendered a considerable area of land below them unfertile.

114. As we have already said, we regard these *ghais* as symptomatic of the tendency of the Brahmini, in its present elevated condition, to force a way for itself into the Kharsua through its left bank. The embankment in question is thus of considerable importance as a curb against this tendency; indeed, so important do we deem it that, loath as we are to suggest that Government should take over more embankments, we think that an exception should be made in this case and that the maintenance of the Brahmini in its proper channel should not be left dependent upon the will and the financial capacity of the zamindars. We recommend, therefore, that Government take over this embankment, that its top be raised to a level three feet above the flood level of 1926, and that it be continued, at the same height, so as to connect with the left flank of the Brahmini weir. The escape across the Janardan *ghai* should be raised so that its crest will be five feet below the level of the flood of 1926 and it should be extended across the channel where outflanking took place into the high ground on the other side. A similar escape should be constructed across the Manika *ghai*, and the Sahara and Bisai *ghais* should be filled in. In this way, a safety valve will be provided to pass the peak of high floods, much of the sand which at present passes through the *ghais* will probably be excluded, and the tendency of the river to break through in this direction will be checked. Should the river ultimately scour out its channel to such an extent as to render this safety valve excessive, the Manika *ghai* might be completely closed.

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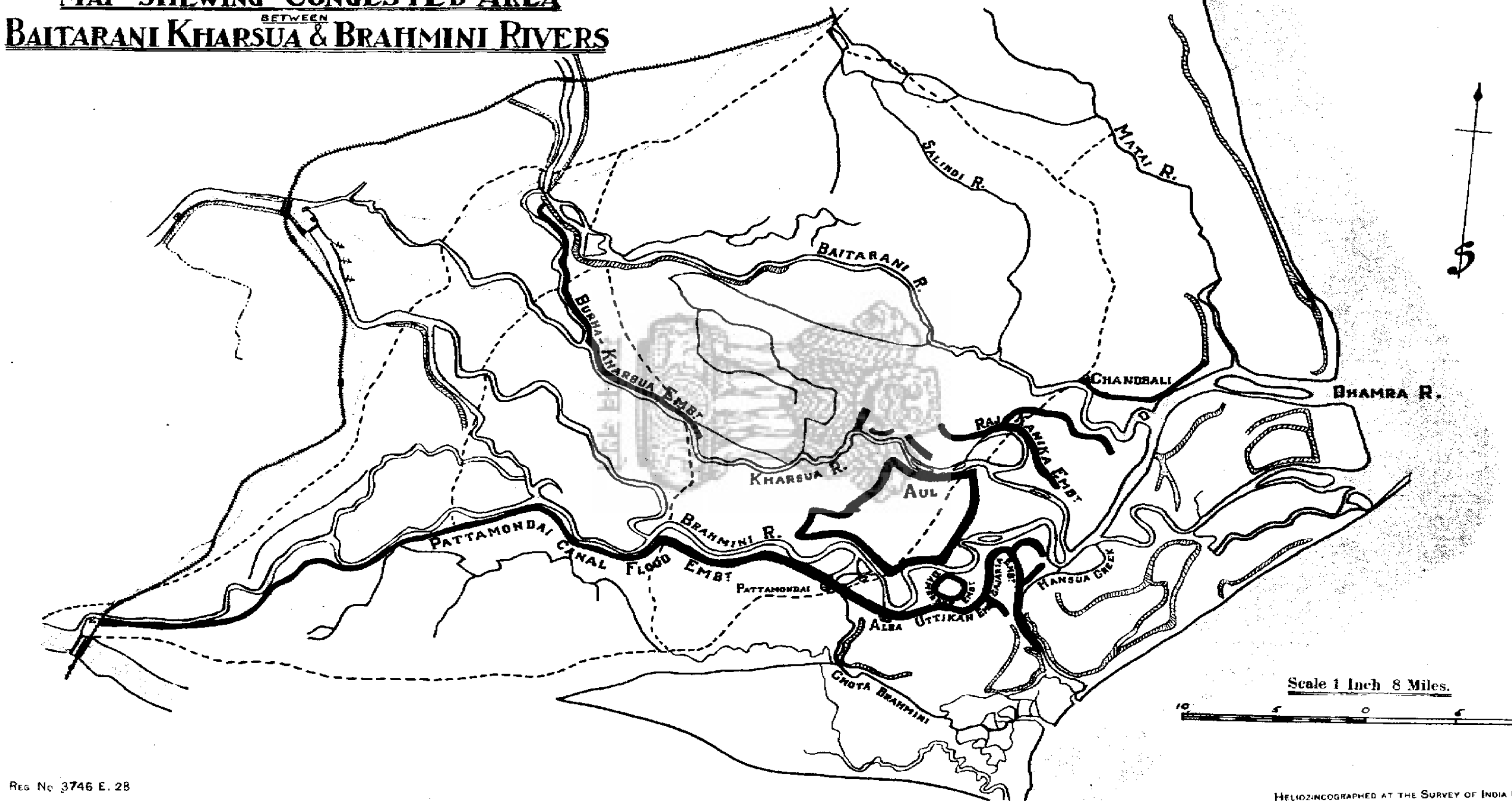
MAP SHEWING CONGESTED AREA BETWEEN BAITARANI KHARSUA & BRAHMINI RIVERS



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CHAPTER X.

The area between the Kharsua and the Brahmini.

115. The tract lying between the Baitarani and its branch the Kharsua, which is irrigated by the Jajpur Canals and is fully protected except at its eastern extremity, calls for no remark and we come, therefore, next, to the area between the Kharsua and the Brahmini. After an inspection of this area and after consideration of the data available regarding it, we have arrived at the conclusion that the excessive flooding which occurs in it is due, almost entirely, to the obstructions which have been placed in the way of the free flow-off of flood water and that such flooding can be largely prevented by the removal of these obstructions.

116. As the accompanying map shows, the two main embankments, one along the left banks of the Burha and Kharsua, which protects the Jaipur Canals, and the other along the right banks of the Birupa and Brahmini, which protects the Pattamundai Canal, converge together, forming a funnel through which the whole of the water of these four rivers and their branches has to flow. The water emerging from this funnel has, however, no free outfall; it is held in by the Raj Kanika embankment along the Kharsua on the north, and by the Uttikan and Gajaria embankments along the Brahmini on the south, these again converging to a very narrow neck at the junction of the rivers. Between these embankments is situated the Aul circuit embankment, like a ball in the neck of a bottle.

117. We had the advantage of inspecting this area during a flood, and, as a result of this inspection, we are convinced that most of the flooding can be directly attributed to the heading back of water by the Gajaria, Uttikan and Aul embankments. The exact depth to which this heading extends is not altogether easy to estimate without taking accurate levels; it is certainly five feet and may possibly be considerably more. There is only one cure for this evil and that is the removal of these obstructions; the result of such removal would be to ensure the rapid flow-off of flood water from a large area over which it is, at present, ponded up to a depth and for a period sufficient to kill the crops upon it.

118. The Gajaria Embankment, a private embankment constructed by the Raja of Kanika, is undoubtedly the worst offender. It has been represented to us that this embankment is essential in order to keep off salt water from the fields, but we cannot accept this statement; it is as a flood embankment that it has been designed and constructed. It should, in our opinion, be entirely removed; we had abundant evidence as to the great relief experienced by the country above it immediately it breached in the great flood of last year. At the same time, the Uttikan embankment, a Government work, which runs in continuation of the Pattamundai flood bank and of which the Gajaria Embankment is a further continuation, should be curtailed so as to terminate just south of Damerpur. The water thus released will probably tend to flow south-eastwards *viâ* the Hansua creek, thus taking the shortest course to the sea, a course considerably less than half the length of its present course *viâ* the Dhamra estuary. The opening up of this creek would give a very desirable new and direct outlet for the Brahmini and would probably facilitate the discharge of the Baitarani also, as, when the Brahmini floods come down first, they back up the Baitarani water at the junction of the two rivers and thus impede the discharge of the latter, diverting it into the low-lying portions of Dhamnagar and Basudebpur. We inspected the Hansua creek throughout its length and it appeared to us to be a suitable channel for the purpose; it is certainly capable of carrying far more water than it obtains at present. Indeed, it is in danger of starvation for lack of an adequate discharge. With such a discharge its estuary would almost certainly improve; there appears, from the aerial survey, to be a second, but inactive, estuary to this

creek to the south of the active one, which would probably also come into play. The main estuary is, however, at present in danger of being killed by the premature reclamation which is taking place in the very low land near the mouth of the creek; all such reclamation should be strictly prohibited, the country being left to be reclaimed, in due course, by the natural deposit of silt upon it.

119. The Raj Kanika embankment on the left bank of the Kharsua is, in our opinion, less harmful than the Gajaria embankment. Its removal is not an urgent matter, as is that of the Gajaria embankment, and action regarding it may be deferred until the question arises in due course in connection with the general policy of removing obstructions to the free flow of the rivers.

120. We have considered very anxiously what recommendations we should make regarding the Aul circuit embankment. This embankment, some 35 miles in length, completely encloses an area of about 50 square miles lying between the Kharsua and the Brahmini. In conjunction with the embankments on the opposite sides of these two rivers it restricts them to very narrow limits and causes serious heading up-stream; it must, therefore, be classed as a bad obstruction to the free run-off of floods.

121. The embankment, part of which is maintained by Government and part by the zamindar, is a very old one; indeed, it is stated to have been in existence for some centuries. During this period the land around it has been raised until the area within the circuit has come to be no more than a cup-shaped depression in the ground, some portions being but little above sea level. The embankment has been raised until it can no longer be maintained, and it is now breached every year, filling the interior with water from the rivers.

122. The plight of the people who live within the circuit is miserable in the extreme. After a recent flood, a quite moderate one, we entered the area from the Kharsua in a boat through one of the open breaches. As far as the eye could reach stretched a tossing sea of grey water, from six to fifteen feet deep, with here and there a village emerging from it, like an island in the waste. And this is an annual occurrence. Every year the villagers sow their *saradh* paddy, praying that no flood will come, but only once in the last ten years have they reaped a crop.

123. As may well be believed, the one cry of the inhabitants of this flood-swept area is for a higher and stronger embankment and, if the Gajaria and part of the Uttikan embankment are removed, as we have advocated, flood levels will probably fall to such an extent as again to make it possible to maintain a circuit round Aul. But to advocate such maintenance would be to treat the matter merely from the point of view of the immediate needs of the people in the circuit and to disregard those of the people living up-stream of it, whose land is unnecessarily flooded owing to the obstruction which it offers to the rivers. Moreover, even were the embankment maintained, history would merely repeat itself. The land outside would continue, by silt deposit, to grow higher and higher than that inside until present conditions would recur in an aggravated form. Taking a long view of the matter, and having regard to the interests of all concerned we have no doubt that the Aul circuit should be removed and we recommend that this be done; it would be unnecessary labour to level the whole of it but so much of it should be levelled as to permit of the free flow through it of the silt-laden water of the rivers, on which the ultimate filling of the hollow must depend. The remainder will, in due course, be washed away. We have received complaints that but little silt is, at present, brought through the breaches; this is probably due to absence of the free flow which we have suggested should now be provided. At the same time, the embanked road which crosses the circuit should be lowered to ground level and maintained only as a fair weather road.

124. The same recommendation applies to the Damerpur circuit, which rings a couple of square miles in a loop of the Brahmini between the Aul circuit and the Uttikan Embankment.

125. We realize that the adoption of this recommendation will do away, for many years, with all possibility of growing *saradh* paddy in Aul or Damerpur. The one chance of the people will be a *dalua* or *rabi* crop and either of these is impracticable without facilities for irrigation. The only means of irrigation will be by pumping and we venture to express the hope that Government will give very special consideration to these areas and will take steps to introduce and popularize, on the easiest terms possible, installations of this nature, in order to afford some means at least of livelihood to the people inhabiting them.

126. Akin to these circuit embankments are the two so-called " tie *bandhs* " of Indupur and Gopalpur. These embankments are tied at both ends to the flood bank of the Pattamundai Canal, and protect a few homesteads and a very small area of cultivation. They are open to the same objections as a circuit embankment; the area within them is gradually becoming lower than that outside and must inevitably, in time, become a swamp. The *bandhs* are, moreover, already so high that no reliance can be placed upon their successfully withstanding a large flood in the Brahmini and they confer merely a false sense of security upon the people whom they purport to protect. Lastly, a failure of a tie *bandh*, by inducing longitudinal scour, cannot but endanger the security of the Pattamundai flood bank itself, which breached so disastrously in 1926. The Indupur tie *bandh* breached in 1926 and 1927, and has not been repaired since the latter flood; we recommend that the breaches in it should be left open and that the upkeep of the Gopalpur tie *bandh* should cease.

127. In several quarters, the opinion has been expressed that considerable relief could be obtained by opening the Chota Brahmini, the head of which is closed, near Alba, by the Pattamundai flood bank, and by escaping a portion of the Brahmini water through this channel into the Jumbu and so into the sea. Our view in this matter is the same as that which we have expressed in Chapter VI, in the case of the Benga and Patpur nalas, and our recommendation follows the same lines. A regulating escape should be constructed on the Brahmini, capable of passing the maximum volume of water which the Chota Brahmini can carry without flooding, this volume being about as great as the Jumbu, which is not a big river, will be able to dispose of in addition to its own supply. It will be necessary to pass this volume under the tail of the Pattamundai Canal; in order to cheapen the work, this tail should be contracted to the bare capacity necessary to maintain a navigation supply in the Gobri Extension Canal and to feed the small amount of irrigation effected from it. It will also be desirable to provide arrangements to enable the Chota Brahmini to be flushed with water from the Pattamundai Canal at times when the Brahmini is not in flood.

128. Several statements were made to us regarding the damage done by the Rowtra breach in one of the detached embankments on the right bank of the Kharsua, near Binjharpur. We were unable to visit the site of this breach but we understand that both the Civil and Public Works Department authorities are agreed that it is desirable that it should be left open. We make no recommendation in the matter, which seems to us to be one for local settlement.

CHAPTER XI.

The area between the Pattamundai and Machgaon Canals.

129. We propose, in this chapter, to deal with the whole of the area which lies between the Pattamundai and Machgaon Canals. In this comprehensive description we include the works at the head of the Mahanadi delta, the two fully protected areas lying between the Pattamundai and Kendrapara Canals to the north, and between the Taldanda and Machgaon Canals to the south of the Mahanadi, as also the Mahanadi proper.

130. The town of Cuttack is situated at the head of the Mahanadi delta, where the main river bifurcates into two branches, the Mahanadi proper running north and the Katjuri south of the town. Some six miles above Cuttack, the Katjuri branch is crossed by a masonry weir, which is tied on the right into the high bank of the river while its left flank is connected, by a long embankment, with the apex of the bifurcation. The object of this weir, known as the Naraj weir, is to maintain a correct proportion between the volumes of water flowing down the Mahanadi and Katjuri, respectively, and to prevent an excessive quantity from passing down the latter river into the Puri district. The maximum flood of the Mahanadi is estimated to amount to about 1½ million cubic feet of water per second; at this stage, the discharge is divided, at the Naraj weir, almost equally between the two branches.

131. Shortly below Cuttack, the Mahanadi bifurcates again, throwing out from its left bank a branch, the Birupa, which runs eastwards into the Brahmini. Almost immediately below this bifurcation both the Mahanadi and Birupa are spanned by masonry weirs, the Mahanadi weir to feed the Taldanda Canal, and its branch the Machgaon, on the south of the river, the Birupa to feed the Kendrapara Canal, and its branch the Pattamundai, between the Birupa and the Mahanadi, as also to provide the necessary supply for Range I of the High Level Canal.

132. There are records of gauge readings at Cuttack for a very considerable period and, as the result of an examination of these, we have found no evidence to show that the head of the delta is tending to rise at present. The high floods rise to-day to just about the level to which they rose one hundred years ago. Indeed, of all the rivers of Orissa, the main Mahanadi, with its straight course to the Bay of Bengal at False Point, seems to us to have attained the most stable regime and it is probable that it actually carries a large proportion of its sand to the sea.

133. We have, during the course of our enquiry, received a number of suggestions for alterations in the arrangements at Naraj. There are some who desire that the weir should be altogether done away with, others who desire that it should be modified. The latter may again be divided into two classes, those who wish more water to be admitted to the Mahanadi and those who wish to see a greater volume passed down the Katjuri into Puri. We consider, however, that it would be inadvisable to accept any of these proposals; the work, as at present constructed, gives an adequate measure of control over the discharges to be passed to each branch during low stages of the river, while at high stages, after control is lost, it automatically ensures an equitable distribution between them. Nor can we contemplate the abandonment of the work, as has been suggested in some quarters, with the consequent possibility of an avulsion of the whole river towards the Puri side. It was, indeed, the threat of such an avulsion which originally called the Naraj weir into being.

134. As regards the protected area lying between the Pattamundai and Kendrapara Canals, this area is enclosed by flood banks on all sides, and its only efficient drainage outlet is between the two locks at the south-east corner at Gandakia, where the Gobri Canal and the Gobri Extension Canal

tail into the Jumbu river. The protected area was flooded to some degree by heavy rainfall in 1925, and was badly flooded when the Pattamundai flood bank breached below Indupur in 1926, both locks being completely submerged in the latter year, and it has been suggested that flooding from such causes could be diminished by increasing the distance between the two locks. We do not, however, recommend that this be done. The two occurrences mentioned were quite exceptional and do not, we consider, constitute sufficient reason for the undertaking of so large and expensive an alteration; in particular, a breach in the Pattamundai bank is unlikely to recur as its factor of safety will be enormously increased if the clearance of obstructions to floods in the Brahmini and Kharsua is effected as we have proposed in the last chapter.

135. Although the matter does not fall strictly within our terms of reference, we think that the local Government might well consider whether any useful object is served by the continued maintenance of the Kendrapara Canal from Marsaghai to the Jumbu river. The amount of navigation on this reach is negligible and practically no irrigation is effected from it. It is, moreover, badly choked with weeds. A saving could be effected in the cost of establishment and repairs were it abandoned, the flood bank only being, for the present, maintained.

136. We now come to the main Mahanadi river. This, as the map shows, is not a single channel but a somewhat complicated network of branches, of which the most important are the Mahanadi, the two reaches of the Pyka, the Chittratola and the Nuna. Considerable changes take place in these branches from time to time, one deteriorating as another opens; but we have found no evidence of deterioration of the river as a whole. It is true that the main Mahanadi channel is now considerably silted but, on the other hand, the Pyka has improved so as to accommodate the increased discharge thrown upon it thereby. We regard these changes as natural variations such as must occur in the branches of a deltaic river.

137. There is considerable flooding, when the Mahanadi is in flood, on the islands formed by these channels, and here again we consider that the remedy lies in the gradual removal of all obstructions to the direct flow of the water to the sea. In the meantime, any raising or extension of existing embankments should be absolutely prohibited. We would except, from this recommendation, short detached embankments on the noses of the islands which merely act as cut waters and serve the purpose of protecting the islands from the direct onrush of the floods. The water should, however, be free to come in from below and submerge the land behind them.

138. It seems to us that these islands are, in general, far more suitable for the cultivation of *rabi* crops than for that of *saradh* paddy, and we are fortified in this view by the evidence given before us by the Manager of the Kujang Estate of the Burdwan Raj which includes a large area of this island land. He stated that, in places where embankments had been breached or cut, fertile silt was deposited on the country and that, although the *saradh* paddy crop was destroyed, bumper *rabi* crops were obtained. To ensure such crops, however, artificial irrigation will usually be essential, and we strongly recommend the inauguration of experiments in these island tracts towards the provision of such irrigation by pumping. Steps should also be taken towards the drainage, by cuts to the rivers, of the several isolated *pats* or depressions in these islands in which, at present, water of considerable depth remains stagnating long after the floods have passed.

139. We have, in Chapter IV, issued a warning against premature reclamation being permitted within the estuaries of the rivers. We noticed such reclamation in progress in the Mahanadi estuary; it should be stopped and further reclamation strictly prohibited. If allowed to continue, it will inevitably cause deterioration of the estuary.

140. The area between the right bank of the Mahanadi, on which the Taldanda Canal runs, and the Machgaon Canal calls for no particular remarks.

CHAPTER XII.

The southern branches of the Mahanadi.

141. The last group of rivers with which we have to deal is that which comprises the southern branches of the Mahanadi, this category including all those which have their offspring from the Katjuri. A short distance below Cuttack the Katjuri bifurcates, the main river flowing to the south-east and its branch, the Koakhai, flowing southwards. The Katjuri flows in a complicated series of channels, forming islands between them, until it loses its identity; the main stream takes the name of the Daib, and it is as such that it is known where it falls into the Bay of Bengal. The Koakhai, on its southerly course, throws off the Kushbhadra on its left bank; shortly below this point it bifurcates, the left branch being known as the Bhargovi and the right as the Daya. The general arrangement of these rivers is not unlike the spokes of a fan, the Daib running south-east, the Kushbhadra south-east by south, the Bhargovi south and the Daya south-west by south; the Daib and Kushbhadra have independent estuaries on the Bay of Bengal while the Daya flows into the Chilka Lake, but the Bhargovi, as explained in paragraph 20, turns sharply to the west as it approaches the sea and, running almost along the edge of the fan, falls into a common estuary with the Daya. The relative importance of these rivers as flood carriers varies from time to time. At present the Daib and Daya are the more active rivers and both appear to be improving, while the Kushbhadra and Bhargovi, which are heavily silted at their heads, are deteriorating.

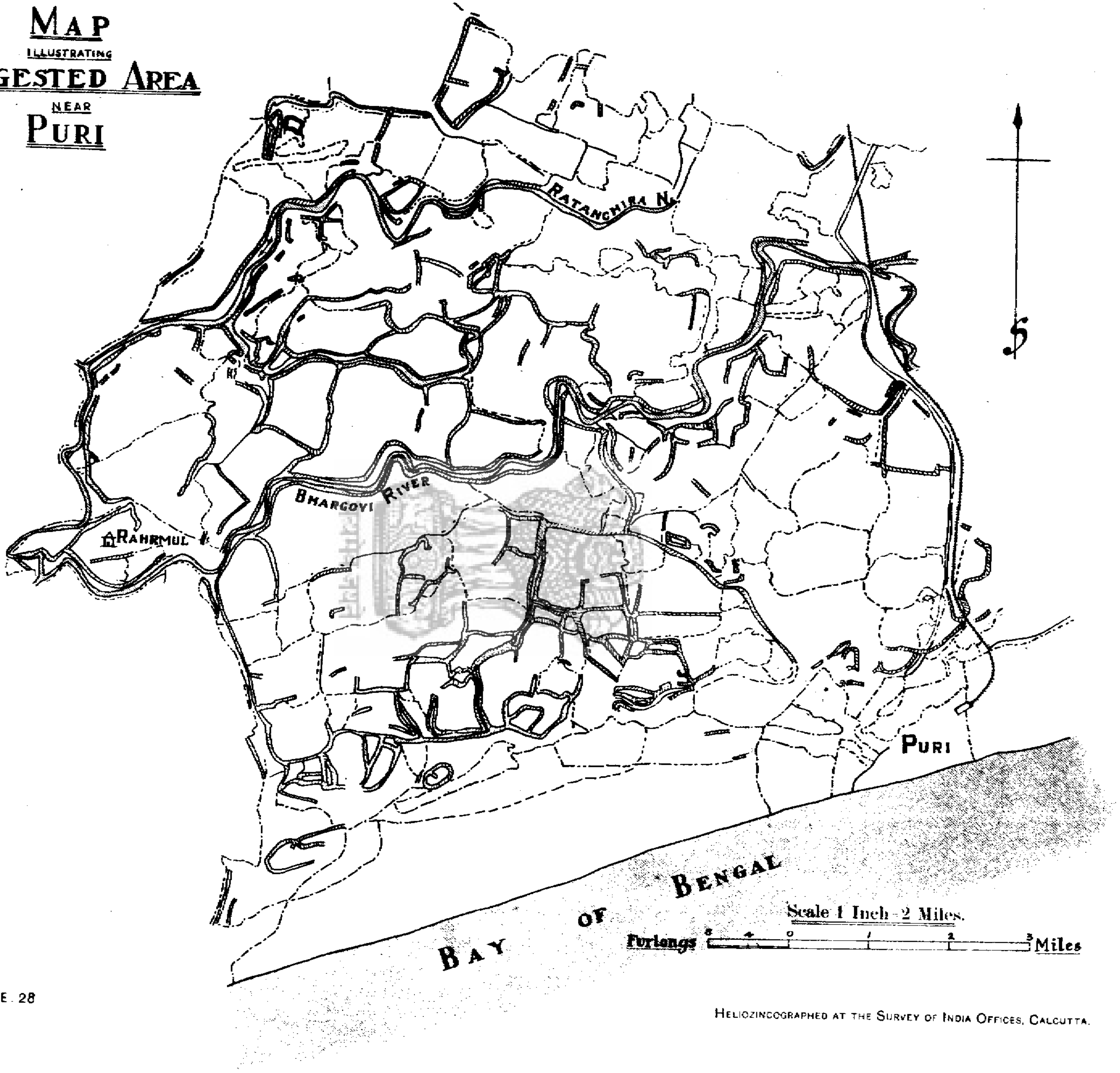
142. As is inevitable in a deltaic country the four rivers run on ridges with valleys between them, the three valleys thus formed being drained by four main internal drainages. Between the Daib and the Kushbhadra lies the Prachi, the Chitrotpala of the Puranas, and in old days a main river connected with the Koakhai; it is the only one of the three drainages which has an independent mouth. The Kushbhadra-Bhargovi basin is drained by the Dhanua, which falls into the Kushbhadra, and the Bhargovi-Daya basin by the Nuna and Ratanchira, which tail into the Daya and Bhargovi, respectively.

143. The problem presented by this group of rivers is the most difficult one with which we have been confronted during the course of our enquiry. Deltaic action in the Puri district is more backward than is the case in Cuttack and Balasore, and its effects are, therefore, even more marked. There is the usual tendency for the rivers to contract as they approach the sea; the Bhargovi, for example, is a wide river at its head but it is hardly worthy of the name of river in its lower reaches, so shrunken has it become. The combined capacity of the four rivers, at their seaward ends, is but a fraction of the volume which they receive from the Katjuri; in such circumstances flooding is, of course, inevitable.

144. Moreover, it is at the mouths of these rivers that the effect of littoral drift is most felt, as explained in paragraph 20. The resulting dunes and sand bars act as yet a further obstacle in the way of the discharge of the rivers into the sea.

145. The condition of the rivers being as it is, it is perhaps only natural that, from early time, the people should have tried to protect themselves from floods by sheltering behind embankments and, in the course of years, a widespread but mostly haphazard system of such embankments has sprung up, each embankment being constructed to save a particular area, without reference to its effect on other areas or on the system as a whole. We reproduce a map of a portion of the Puri District taken from the map of Orissa, on the scale of one mile to an inch, which has been specially prepared at our request by the Settlement Department and on which all embankments are shewn. In the light of this map a further description seems superfluous. As must happen in such cases, the level of the protected areas has fallen below the level of those open to the flood. We have little hesitation in

MAP
ILLUSTRATING
CONGESTED AREA
NEAR
PURI



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saying that it would have been better for the country as a whole had no single embankment been raised throughout the tract; floods there would have been, but they would have been shallow and would quickly have run off. But what has been done, has been done; with the levels of the country as they are at present any sudden removal of protection would cause disaster, and the policy of opening up will have to be pursued slowly and with caution. In the meantime, the strictest control should be exercised to guard against the construction of new and the raising or lengthening of old embankments.

146. Another marked factor in the present situation in the district is the large amount of premature reclamation which has taken place along the sea face. There are large areas, covered with villages and attempting to support a numerous population, which are only a few feet above the mean level of the sea and from which the tides have to be excluded by means of salt *bandhs*. If such areas become badly flooded, their rapid drainage is practically impossible; the troubles of the people are really due to the fact that they are living in places on which nature has not been permitted to accomplish her work and which are not yet really fit for human habitation.

147. We shall now proceed to deal with the rivers one by one, commencing with the Daib and working southwards. A few miles below the off-take of the Koakhai, the Katjuri bifurcates and throws off the Surua from its right bank; the latter is at present the main stream of the river, the Katjuri proper being badly silted. There is an embankment along the right bank of the Surua, which continues below the point where that branch and the Katjuri rejoin one another down to the point where the latter again bifurcates and throws off the Daib on its right. The upper portion of this embankment is maintained by Government, the last few miles by the zamindars; a breach, known as the Mankho *ghai*, took place in the zamindari portion in 1925 and 1926 and, although it was closed in 1927 by the district board who are using the embankment as a roadway, the people are pressing that Government should take it over and maintain it. We are opposed to any such suggestion. We have received evidence to the effect that, when the *ghai* was open, considerable relief was experienced lower down the Daib; we consider that it should never have been re-closed, and that there should be machinery to restrain a district board from taking action of this nature without consultation with the Superintendent of Embankments. We inspected the site of the breach and it appears to us probable that it will open again in the next high flood; if so, it should not be fully closed, but a paved escape should be provided in it, to serve as a safety valve and to pass part of the peak of the flood. The area over which the water will flow is low and will, in the long run, be raised by silt deposit from the escape; when this has been effected it should be possible to remove the embankment altogether, in pursuance of the general policy which we have recommended for adoption.

148. Some four miles below the offtake of the Daib, the Katjuri, which is here in a very silted state, bifurcates again, into the Olanka on the left and the Biluakhai on the right. The Olanka was, in the past, a flood carrying channel of some importance, but, when the Orissa canals were built, it was completely closed by the construction across it of Distributary No. 19 of the Machgaon Canal. In its lower reaches it divides into two channels, the Chota Olanka running into the Daib and the Bara Olanka to a separate estuary, the Jatadhar. The Bara Olanka has also been closed by the tail of the Machgaon Canal.

149. From the aerial survey it appears that the Jatadhar estuary is open and in good condition, and this being so, and having in view the small discharge capacity of the southern estuaries in general, it seems to us a thousand pities that it should not be utilized. The passage of a reasonable discharge in this direction would considerably relieve congestion lower down the Daib. We therefore recommend that the Olanka be re-opened. A project for this purpose should be drawn up after the necessary detailed surveys and investigations have been made; in the absence of such surveys we can give only a general outline of what we consider should be done. In the first place, the maximum volume of water which the channel is capable

of carrying should be determined, and a high level escape constructed across its head capable of passing this volume; we may mention that, in the flood of 1872, it was estimated that about 25,000 cubic feet per second were accommodated in the Olanka, of which 10,000 subsequently passed down the Chota and 15,000 down the Bara Olanka. If only the peak of the floods be passed into the Olanka the heavier sand should be excluded from the channel, a fact which will serve to keep the estuary open. The Machgaon Canal distributary which at present closes the river can, if considered desirable, be syphoned under the escape. Should it be found that there is a tendency for the water to flow back into the Daib by the Biluakhai, this tendency should be counteracted by the contraction or, if necessary, the complete closure of this river. The investigation which we have suggested should extend to the Bara and Chota Olanka, and efforts made to take as much water as possible down the former to the Jatadhar; the last couple of miles of the Machgaon Canal, which crosses the Bara Olanka, should be abandoned.

150. The Cross Katjuri served, before the closing of the Olanka, as an escape from that river into the Mahanadi; it is now closed, being crossed at its head by the Machgaon Canal and at its outfall by the Taldanda Canal. We have considered whether this channel should also be opened but have decided against such a course; it has deteriorated greatly and would require double embanking throughout. It is already flushed to a certain extent in its lower reaches by drainage water from the area to the west and by water escaped from the Taldanda Canal; it would, we think, be advisable on sanitary grounds to arrange for its upper reaches being flushed from the Machgaon Canal.

151. In general, the recommendations which we have made in the last chapter for application to the islands situated between the northern branches of the Mahanadi apply equally to the islands situated between the branches of the Daib. To quote a specific instance, our attention was called to one such island protected at its nose by Embankment No. 92 and on its flanks by Nos. 88B and 89B. We consider No. 92 to be unobjectionable, since it merely serves to break the force of the water, but Nos. 88B and 89B should be removed, this being effected gradually from the lower end, thus letting in water behind them and raising the land.

152. We come now to an exceedingly difficult area, namely, that situated near Kakatpur, close to the sea, between the mouths of the Daib and Prachi. We have received several representations from this area, which is undoubtedly badly flooded, but, in the absence of a complete and modern survey, we are unable to make definite recommendations regarding it. Our only source of information as to its levels is the contour survey of 1923, which does not give sufficient or sufficiently accurate information to justify us in suggesting final remedies. The tract should be made the subject of a special survey and investigation by an officer charged to report fully upon it. It seems to us probable that it has been prematurely reclaimed and that much of it is but little above sea level while parts are below the level of the highest tides; if this is so, complete relief may prove impossible. But various suggestions which have been made for its partial relief may be practicable. Chief among these is the straightening of the channel of the Prachi, which at present backs up water into the area; our remarks regarding the general undesirability of attempting to straighten the courses of rivers do not apply in their full force to an interior drainage such as this which carries little or no sand. The aerial survey shows a good mouth to the river and it may be that, by straightening, its capacity for discharge can be improved. Representations have also been made to us for the closing of the Olai *ghai*, a breach in the Government embankment on the right bank of the Daib; this should be looked into but if, as appears probable, the *ghai* discharges into very low land, it will, we think, be preferable to leave it open and to confine the investigation to the possibility of draining the land in question by a cut into one of the neighbouring tidal creeks. The effect upon flooding of the district board road should also be examined, as should the suggestion for a cut from the Kadua to the Prachi,

to relieve the area on the right of the latter river. We are definitely opposed to the raising of the right embankment of the Daib, which has been recommended by some witnesses, and consider that urgent measures should be taken to prevent the construction of further private embankments within the area.

153. The investigation of the possibility of improving the channel of the Prachi should not be confined to the portion near its mouth but should be extended so as to include the whole river. There is an escape in the left embankment of the Kushbhadra, known as the Ramchandrapur escape, which discharges into the Prachi and, while those in its vicinity have no complaint to urge against it, as it brings silt to their fields, it is undoubtedly the cause of flooding lower down. We certainly do not support the proposal to give the Prachi a head on the Koakhai to convert it into a main river, but it would be of great advantage if it could be improved throughout its present length and so converted into a more efficient interior drainage than it is at present. Not only would such improvement enable it to carry safely the water from the Ramchandrapur escape but it might also enable a further escape to be made at Prataprudrapur, lower down in the same embankment, where a breach occurred in 1926. An escape at this point, coupled, possibly, with a leading cut to the Prachi, would greatly relieve the lower reaches of the Kushbhadra; the construction of such an escape is, however, dependent on the discharging capacity of the Prachi being first increased.

154. It has been represented to us from many quarters that an attempt should be made to reopen the old Patharbuha branch of the Kushbhadra, this being the channel by which stone is believed to have been brought to Kanarak for the construction of the temple there. We inspected the channel, or at least the vestiges of it that remain, and regard the scheme as impossible. The branch itself has practically, and its mouth completely, disappeared. To reopen it would entail the excavation of a cut through miles of sand with little or no prospect of being able to maintain it.

155. The prospect of being able to keep open a mouth for the Kushbhadra proper is a better one. A cut was made during the winter of 1925-26 through the sand dune which masked it; this cut was 750 feet wide, but it opened to a width of 1,300 feet during the floods of 1926. There were no large floods in 1927 and the cut closed to a considerable extent, but not completely; we understand that it re-opened with the first flood of the present year. This is an encouraging result and we consider that further experiments of this nature are justifiable and should be undertaken.

156. The next basin for consideration is that lying between the Kushbhadra and the Bhargovi, which is drained by the Dhanua. One of the main causes of the flooding in this basin is the discharge into it of the water from two escapes, the Jogishai escape in the right embankment of the Kushbhadra, and the Achhutpur escape in the left embankment of the Bhargovi. We have received many complaints regarding the sand carried and floods caused by these escapes, and there is a strong feeling in favour either of their length being curtailed or of their cills being raised. We are, however, unable to recommend any alteration in them being made until such time as the Kushbhadra and Bhargovi are able to dispose of their discharges to the sea, the Kushbhadra by the means we have already adumbrated and the Bhargovi by the cut from the Sur Lake which we propose below. Then, but not until then, will it be possible to raise the level of the escapes without inviting breaches elsewhere and converting a controlled into an uncontrolled flood. Care should, however, be taken that homesteads in the immediate vicinity of the escapes are adequately protected from any direct rush of water upon them.

157. The drainage of the Dhanua basin is very largely obstructed by private embankments, several of which run at right angles across it, as does also the district board road from Pipli to Nimapara. The waterway provided in this road is inadequate; indeed the only type of road which can function satisfactorily in such a position is that which we have advocated in Chapter VIII, for the road from Bhadrak to Chandbali. We

recommend that the question of converting this road into a metalled surface road with vented causeways be considered, a grant being made to the district board, if necessary. As regards the embankments in the basin, while these are obstructive to a degree, their removal at present would probably put much of the area behind them out of cultivation. If, however, the cut from the Sur Lake, which we propose below, proves successful in rapidly draining the area, the embankments will become superfluous and their removal will follow automatically.

158. The Samang Pat and the Sur Lake lie at the bottom of the basin between the Bhargovi and the Kushbhadra, connected together by the Athara nala, a connection which has deteriorated and the bed of which is now cultivated, but which could be improved without much difficulty. They act as balancing reservoirs to the rivers in their neighbourhood. A portion, at least, of the water which these rivers cannot carry to their mouths accumulates in the two lakes, to be discharged slowly afterwards. Were it possible to give the lakes a direct connection to the sea so that they would discharge into it when a prescribed level was reached, a great improvement in the congestion which at present takes place would be effected. The Sur Lake is in a position to draw water from the Bhargovi on the west, through the Kanchi which already connects them, and from the Dhanua on the east, provided that the existing dividing embankments are removed. Any relief to the Dhanua will be also a relief to the Kushbhadra, into which the Dhanua flows.

159. Projects have been drawn up in the past for the drainage of the Sur Lake, but have been put aside as impracticable; we do not, however, believe that the scheme is in any way impossible and, since it seems to afford the key to the whole trouble in central Puri, we consider that it should be again investigated. We have not the material upon which to base a detailed project; a careful survey with complete levels, as also an accurate series of tidal observations, will have to be made before such a project can be prepared. From the levels in our possession, approximate only as they undoubtedly are, there seems to be no doubt as to the theoretical feasibility of the scheme. A large area of *dalua* paddy is grown both in the Sur Lake and in the Samang Pat; it is undesirable to interfere with this cultivation either by draining the water too low or by allowing salt water to enter the lakes, and this consideration must be a governing feature of the project. The type of work which we have in mind is as follows. Set back at some little distance from the sea, a weir wall, with floor below, will be erected; its height will be either that of the highest tide in the dry season or the height at which water must be held up for the *dalua* crop, whichever is greater. From this wall, a cut some two miles long and some three to four hundred feet wide, will be excavated to the Sur Lake. As the high flood level of the Bhargovi at its junction with the Kanchi rises to about 15 feet, and that of the Sur Lake to about 12 feet, above highest spring tides, there can be no doubt that the water will flow as desired. There would be no tidal locking in such a channel, which would run continuously throughout the twenty-four hours.

160. The only question is, therefore, whether it is possible to construct the wall and cut, and, when constructed, to maintain them against wave action and drifting sand. We certainly do not believe that either is impossible. That construction will be difficult and expensive we are prepared to admit, especially in view of the high spring level which obtains; it may very probably be found necessary to pack the sides of the channel with graded rubble to support them and prevent the infiltration of sand. As regards maintenance, wave action can be avoided by setting back the weir some little distance from the sea face; the channel below will silt in the dry season but be rapidly scoured out again when discharge commences. Sand drift can, we believe, be largely obviated by excavating the cut under the protection of the existing casuarina plantation and by protecting it with further casuarina, goatsfoot creeper, cactus and the like. We regard this project as so important that we are prepared to recommend that, once the necessary surveys and observations have been made and the details

settled, it should be put in hand even if it is considered that a risk of failure is involved. The risk, if risk there be, should, we think, be faced.

161. Passing, now, further to the west, it has been suggested that a cut should be made in the bed of the Sonamuhi river, which is now hardly recognizable as such, to serve as a drain for the area lying between that river and the Bhargovi. This area is enclosed on all sides by embankments, and drainage through these embankments is at present impossible, as there is no outfall. We are unable to give an opinion upon this scheme in the absence of comparative levels; there appears to be but a very small fall in the Sonamuhi but, as it carries little sand or silt, it may be possible to keep the drain, if excavated, open. The most that we can do is to recommend that the matter be further examined.

162. Another proposal which has been put before us is that the Naya Nadi, an old artificial channel which connects the Bhargovi with the Sonamuhi, should be excavated so as to relieve the former. It has silted badly and the bed is in many places under cultivation. It might be included in the examination referred to in the previous paragraph. If, as may possibly be the case, the flood levels of the Bhargovi and Sonamuhi at the offtake and outfall of this channel are the same, no useful purpose will be served by its re-opening as it will merely deteriorate again.

163. The next area for consideration is the Brahmagiri *thana*, which lies in the angle between the Bhargovi and the Chilka Lake. This, again, is a very low area prematurely reclaimed; in fact it has, in the past, probably suffered more from the incursion of salt water than from floods. Its main crop is *dalua* paddy; to protect this crop from the salt water of the lake, Government, in 1926, reconstructed the old *nuna*, or salt, embankment in the west of the *thana*. Since that time the conditions in the tract have improved somewhat, but no real betterment can be hoped for until such time as the area has been raised by silt deposit. Obstructions to the free flow of silt-laden water through the tract should, so far as possible, be removed; we are entirely opposed to the proposal which has been put forward to extend the left embankment of the Bhargovi to meet the salt *bandh* and thus form a circuit about the area.

164. Lastly, we come to the Bhargovi-Daya basin, drained by the Nuna and Ratanchira. There are three escapes in the left embankment of the Daya, the Belamara, Madhipur and Kanti escapes, which discharge water into this area. Although complaint has been made of the flooding caused by these escapes, we cannot recommend any alteration in them; if their discharge is reduced, it will merely lead to breaches elsewhere. Nor can we recommend the raising of the left embankment of the Daya, for which a project has actually been prepared. A difficult situation is already arising on this river. The right bank, which is un-embanked, is being raised by the deposit of silt to such an extent that the left embankment is becoming unstable; if this embankment is raised the process will merely be repeated until it can no longer be maintained when a double catastrophe will occur, the left bank being flooded to great depth, and the right bank being left high and dry, deprived even of the water necessary for beneficial irrigation. Our inspection showed that the left embankment has deteriorated considerably; we recommend that it be gradually abandoned, from the bottom upwards, but it should, in the meantime, be maintained in an efficient condition at its present height, so as to prevent its breaching in unexpected, and probably inconvenient, places.

165. The Monaguni river falls into the Daya on its right bank and is double embanked up to the meeting point. This is to be deprecated; the river, thus harnessed, is likely to form an interior delta for itself in the bed of the Daya, thereby blocking the latter river. The Monaguni embankments should be discontinued at least two miles from the Daya bank.

166. Representations were made to us urging the construction of a right embankment on the Daya below the Monaguni junction. This is, in our opinion, a request which should be firmly refused.

167. The Nuna and Ratanchira, which form the interior drainage channels of the Bhargovi-Daya basin were, in the past, hemmed in by Government embankments on both sides; these embankments have now been abandoned and on no account should they be permitted to be restored. It is, as will readily be understood, folly so to embank an interior drain as to prevent the drainage of the country from entering it.

168. Finally, as regards the Chilka Lake, we consider that all attempts at the premature reclamation of the bed of the lake should be sternly prohibited. This lake, which has an area of about 450 square miles, forms a balancing reservoir for the flood water of a large portion of the Puri district. The level of the lake in the monsoon is only a few feet above that of the sea, and the variation in the water levels is small. Any contraction of its surface will cause increased flooding on the low land on its margin and merely lead to a repetition, in the future, of the trouble and distress which we have been appointed to devise remedies to remove.

169. The maintenance of an open mouth for the Chilka Lake is, in our view, a matter of prime importance. The present mouth should be carefully watched and, should it show any tendency to close and not to reopen during the monsoon, further measures, such as those taken at the mouth of the Kushbhadra, should be taken here also.

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CHAPTER XIII.

Organization.

170. If the recommendations which we have made in the preceding chapters are carried out, it is clear that a very much larger establishment will be required for the purpose than is at present maintained by the Irrigation Department in Orissa The existing staff is inadequate to do the work which should, even now, be done ; it would be quite impossible for it to do more. Two divisions are in operation. The Mahanadi division includes the area bounded on the north by the Birupa and Brahmini, on the south by the Daib, and on the east by the Bay of Bengal, together with a small tract lying between the lower reaches of the Kharsua and the Brahmini and another to the south of the Daib, embracing in all 175,000 acres of irrigation. The Balasore division covers the rest of Orissa, from Bengal to Madras, a distance of over two hundred miles, and includes 70,000 acres of irrigation from the Dudhai and Jajpur Canals and from the three Ranges of the High Level Canal.

171. In circumstances such as these it is inevitable that the officers in question should apply themselves primarily to the maintenance of the irrigated area, and that the question of floods should have to be dealt with as a secondary consideration. The upkeep of a great length of agricultural embankments is, it is true, in their charge but the relative importance placed on this class of work is shewn by the establishment allotted to it. In the whole of the Puri district there are but two subordinates, and the charge of one of these overlaps into Cuttack. The other, with the assistance of a single permanent peon (and of four additional temporary peons during the monsoon), is responsible for keeping in order two hundred miles of embankments in a country where the difficulties of communication are exceptionally great. Puri has not been regarded as of sufficient importance even to warrant the formation of a subdivision for its needs ; the nearest subdivisional officer is stationed in Cuttack. In the Cuttack and Balasore districts there are no special embankment officers, the embankment work being done by the irrigation staff. It is, naturally, out of the question to expect that this meagre establishment should look to more than the actual works immediately in their charge ; it is a physical impossibility for them to visit and inspect the outlying prohibited areas and to prevent the unauthorized construction or raising of embankments within them. Indeed, as already stated, it has been customary to reduce the patrol establishment during the winter, which is just the time when these infractions of the law occur. Still less is it possible for them to give any real attention to the collection, collation and study of hydraulic data, which is the first step towards the elucidation of measures for the prevention of flooding. The whole of the general question of floods and their remedies seems, indeed, except in so far as a few gauges have been read daily as a matter of routine, to have received but little real and systematic attention at the hands of the engineering establishment for over fifty years from the time of Mr. Rhind's report of 1872 to that of the inauguration of the contour survey of 1923. We can, at least, discover no trace of any general enquiry into or discussion of the problem as a whole during this period.

172. It is a matter of some regret to us that we have been unable, in this report, to deal more fully with the hydraulics of the rivers under discussion. But much of the data which we have obtained has proved, on examination, to be unacceptable, and we are unwilling to commit ourselves to stating conclusions which may, ultimately, prove to be based on incorrect premises. We have, for example, found old records which, when compared with new, gave promise of showing where and exactly to what extent river beds have risen in the last seventy years, only to discover that a decided element of doubt existed as to the datum to which the older observations were referred. It has also been impossible to trace, in some cases, upon what value of the mean sea level past gauge readings have been based. These doubts render a vast amount of the available material almost valueless.

173. We shall now describe the organization which we recommend for carrying out the general policy embodied in this report, for executing the various works referred to, and for the collection of the data necessary for the comprehensive study of the whole question. It is to be remembered that deltaic action is continuous, and that nothing is final in a country of this nature. We do not desire to leave those who will come after and have to deal with the problems of the future in any such uncertainty as we have experienced as to the reliability of the records.

174. The first recommendation which we have to make is that the work connected with drainage and embankments (other than the embankments which form an integral part of the canal systems) should be the charge of a whole-time Superintending Engineer, who will function also as Superintendent of Embankments. For the present, at least, we consider that this officer should not also be in charge of irrigation in Orissa. It is most undesirable that he should be in a position such that, when decisions have to be taken upon questions where irrigation and drainage are incompatible, he will be torn between the conflicting claims of two sides of his own work. His duty should be to protect the interests of drainage ; if, in the exercise of this duty, he finds himself in opposition to the claims of irrigation, the matter should be referred to the Chief Engineer, and the final decision should rest with the local Government, taking an impartial view of the whole position. We do not believe that any man can efficiently serve two masters pulling different ways, as an irrigation-cum-drainage Superintending Engineer would have to do. Moreover, we think it most important that the Superintending Engineer should be freed from the additional work which the administrative charge of the canals would impose upon him ; he should have time for study and compilation of the data which will be collected under his direction, as also for personal inspections of the outlying tracts within his jurisdiction. For much of the year, indeed, we anticipate that he will be almost continually in camp as upon him will rest the responsibility for recommending the order in which obstructions are to be removed.

175. We realize that this separation will cause inconvenience ; a single division should suffice for the executive control of the Orissa Canals and this division will be isolated from any other irrigation work. Two possible means of overcoming this difficulty suggest themselves. The Orissa irrigation division might be placed under the Chief Engineer in the same way as the Cuttack division has been placed directly under the Chief Engineer of the Buildings and Roads Branch, or it might be attached to the Son Circle ; there are many cases in India of isolated divisions attached to circles in other portions of the province.

176. Under the Superintendent of Embankments there should be two permanent embankment and drainage divisions, the headquarters of one of which should be located at Puri. In addition, a temporary division will be required for the period during which the works which we have recommended for execution are under construction.

177. We make no recommendation as to the subdivisional and subordinate staff required ; it must be adequate to keep a watch over the whole of Orissa, with a view to check the erection of unauthorized embankments, to carry on the ordinary maintenance of works in its charge and to prosecute the extensive enquiries which will be necessary in connection with the gradual removal of obstructions. We would merely note that it will be necessary to provide this establishment with suitable means of conveyance in the form of boats, etc., as otherwise an officer may be unable for long periods, to visit the more inaccessible areas within the limits of his charge.

178. Before full effect can be given to the policy which we have advocated it will, we think, be necessary to have an accurate contour survey made of the whole of Orissa. That made in 1923 is quite inadequate for the purpose, and, in any event, covers only part of the area. We do not believe that a satisfactory survey of this nature can be made by the Public Works Department, as it is work of a highly specialized nature ; it will be preferable, and probably cheaper in the end, to invoke the assistance of the

most experienced agency available and to entrust the work to the Survey of India. The opportunity should also be taken to have those features of the country which are liable to change, such as the banks and estuaries of rivers, resurveyed ; we have found the existing maps extremely unreliable as regards these features and, in many cases, the estuaries as shown upon them are hardly recognizable as the same as those shown in the recent aerial survey. A further task which should be entrusted to the same agency is that of running accurate lines of levels on selected routes throughout the country, leaving bench-marks at frequent intervals and connecting them with the more important gauges. We are satisfied that many of the existing canal bench-marks are quite unreliable. Various data have been in use in Orissa from time to time (even at present different data are adopted north and south of the Salindi) and there is seldom satisfactory evidence to show to which of these various data the level of any particular bench-mark refers. The same applies to the zeros of many of the gauges. Henceforth we recommend that the present G. T. S. datum be adopted throughout Orissa, important previous records, such as high flood levels, being revised to correspond if the datum to which they are referred is definitely known.

179. Supplementary to this survey, a survey will have to be made by the Public Works officers of all private embankments in Orissa, showing their position, length and height. This should be accompanied by frequent cross sections, the whole being referred to reliable bench-marks. Without such a survey, any unauthorized addition to or raising of an embankment will be almost impossible to prove in a Court of Law.

180. The primary record of the vagaries of a river is to be found in the gauge readings, and the recording and analysis of such readings will form an important portion of the work of the new organization. The number of gauges read at present is far too few to supply any accurate information as to surface slope, congestion, and the like ; on the Baitarani, for example, there is only a single gauge between the head of the delta and the sea. Gauges should be fixed on all the main rivers and branches in sufficient number to enable the surface slope to be accurately determined ; they should be so situated as to be accessible even in the highest floods, which is not always the case at present, and the top portions should be constructed in masonry, being carried to a height some three feet above the highest recorded flood level. A bench-mark should be constructed near each gauge, which should be connected by the Public Works Department officers with one of the main lines of levels which we have suggested should be run by the Survey of India, and the proper maintenance of these bench-marks should be regarded as an important duty of the officer in charge. In this way, if a gauge is damaged or destroyed, another can be installed with the certainty that its zero is the same as that of the one replaced. Important gauges should be read morning, noon and night throughout the year, and less important gauges at the same times during the monsoon only, but, during the actual passage of floods, once a predetermined level has been exceeded, all gauges should be read not less frequently than hourly so as to enable proper hydrographs or flood duration diagrams of the site to be prepared. No gauge reader should have to read more than one gauge (except where gauges are close together, such as the up-and down-stream gauges on a weir) and readers should be provided with time-pieces to ensure correct synchronization. Where it is necessary to appoint temporary gauge-readers for gauges which are read only during the monsoon, every effort should be made to obtain the services of the same men year after year. The gauge registers thus compiled should be carefully maintained as permanent records, and should be examined at short intervals by both the Executive Engineers and the Subdivisional Officers in order that any mistakes or discrepancies may be discovered and corrected at once and not be left upon the record to puzzle those who have to deal with it in future. We recommend the adoption of the system in force in some provinces under which the principal gauges are communicated daily to the Subdivisional Officer, who enters them in his gauge register in his own hand. This system ensures that any obvious discrepancy comes immediately to notice.

181. A most important class of gauge, which has been much neglected in Orissa, is the tidal gauge. There is no record of tidal readings even at so important a point as Chandbali. In addition to the few now in existence, gauges should be fixed throughout the length of the tidal basin of each river, as well as at the mouth of the Daya and near Arkhkuda in the Chilka Lake and at selected points on the sea face. In the case of sea face gauges, special gauge houses, designed to damp wave effect, may be necessary in some places ; where there are provided, the installation of automatic gauges may be considered. Tidal readings should be taken for several years ; it will suffice if sea face gauges are read only during the monsoon but those in estuaries, rivers, and the Chilka Lake should be read throughout the year. All tidal gauges should be read hourly from 6 A.M. to 6 P.M., and, in addition, at high water, low water, high water slack, and low water slack, the time of each being noted, so as to enable the correct tidal curve to be obtained. Any extraordinary occurrence, such as a storm, should invariably be noted in the register. The exact point in each river to which the tide extends should also be ascertained and recorded.

182 We understand that, in general, the system under which rainfall gauges in the catchments of the rivers are read and communicated is reasonably satisfactory, but additional gauges appear to be required in the Baitarani catchment and the co-operation of the Keonjhar State should be invited with a view to their provision. The results of the enquiry now being conducted by Mr. Mahalanobis into the correlation of rainfall and floods in Orissa will, we anticipate, be of great value to the new drainage organization.

183 Another important record which should be maintained is that of the improvement or deterioration of the rivers and their branches, and for this purpose frequent cross sections of them should be taken, extending well on to the countryside and beyond the embankments if any exist. The sites of these cross sections should be carefully selected on straight reaches of the river and demarcated with permanent pillars on each bank, a bench-mark, with its reduced level inscribed on it, being fixed on each such pillar. A careful record of the sites of these cross sections should be maintained ; we have found, among the older papers, a number of most beautifully finished drawings of cross sections taken fifty years ago which might have been of the utmost value to us had they contained any information which would enable them to be accurately identified, or the datum on which the levels were based to be determined. It is not necessary to observe every cross section every year; it will ordinarily be sufficient if they are taken at five-year intervals, the sections being divided into five groups and one group being taken annually. But, after an exceptional flood in any river, all the cross sections of that river should be re-taken, to enable the effect of the flood to be gauged.

184. We have, in our report, given the generally accepted maximum discharges of the rivers, but these discharges are based on somewhat slender evidence, and, in some cases, on formulae long since abandoned as inaccurate. We consider that an effort should now be made to re-calculate them, and also to calibrate the more important gauges so that, the gauge being read, the corresponding discharge will be known. This calibration should be done by calculation from the surface slopes aided, where possible, by current meter observations. We further recommend that a discharge site should be selected in the gorge of each of the main rivers, gauges being read at these sites and periodical discharges observed. We also think that an attempt should be made to compute the discharge of the great flood of the Baitarani of 1927, the estimate of which is approximate in the extreme. This may be possible from an investigation higher up the river, where it is confined between banks, if reasonably accurate information as to the height to which the water rose can still be obtained either by enquiry or from marks left by the flood.

185. We deem it most desirable that, after every exceptionally high flood, a special report should be compiled by the new drainage circle containing all observations regarding it. Immediately the flood has subsided, and while details are still fresh in the memory of those in the vicinity, a special

officer, with no other work to do for the time being, should be sent to the areas affected to make observations of the level to which the flood rose up and down-stream of breaches and escapes, the time of the occurrence of the breaches, the depths of water on the land, the direction of flow over the land, the occurrence of sand spill, and cognate matters. The approximate discharge of the flood should be ascertainable from these observations. A self-contained report of the flood should then be compiled, accompanied by flood-duration diagrams of the principal gauges and by information as to rainfall, state of the tides and other relevant considerations. We suggest that the Bengal-Nagpur Railway authorities should be asked to take similar action, sending out an officer to record flood levels up-and down-stream of their bridges and waterways. It would probably be advantageous if, after such a flood, the Public Works and Railway officers were to meet and discuss the results obtained.

186. We wish to make it clear, if it is not clear already, that we are not proposing that the information which, in this chapter, we have suggested should be collected, should be compiled merely as a matter of theoretical interest or as an addition to the already voluminous literature on floods. Rather, it will form the foundation upon which all proposals for relief will rest. With complete information of the nature which we have prescribed, an engineer should, without leaving his office table, be able to put his finger upon the point where congestion is taking place ; this being known, it is a simple matter to go out into the field and discover what is causing it. Without it, the engineer is working in the dark. He may possibly be able, from the more obvious signs, to diagnose a simple case and to sketch the outlines of a cure, but, for the filling in of these outlines, detailed information, scientifically compiled, is essential. In its absence, it will usually be impossible for him to discover the more intricate complications, which may be at the root of the whole trouble. It is the lack of information of this nature which has, in many cases, prevented us from developing our proposals in greater detail, and which has constrained us to leave the feasibility of certain schemes over for future investigation.

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CHAPTER XIV.

Legislation.

187. We propose, in this chapter, to suggest certain changes in and additions to the law regarding embankments in Orissa which we deem essential or desirable for carrying out the policy which we have advocated.

188. The embankments which protect the irrigated area are regarded as part and parcel of the canal systems and, as such, are governed by the provisions of the Bengal Irrigation Act, 1876 (Bengal Act 3 of 1876). Under section 3 (*i*) (*b*) of this Act, a canal is defined so as to include all embankments connected with it, and Government have the same rights regarding and control over such embankments as they have over the canals themselves. Once a river or stream has been notified under this Act, any Canal Officer may, under section 7, remove any obstructions from the channel. The penal sections 93 and 94 provide for all offences likely to lead to damage to or to the deterioration of the embankments or to the obstruction of drainage in the fully protected area, and section 95 empowers the convicting Magistrate to order the removal of an unauthorized obstruction, or to repair the damage in respect of which the conviction is held, at the cost of the person responsible. The powers conferred by this Act appear to us to be adequate, and no amendment of or addition to it to be required.

189. The embankments in the semi-protected area are governed in the main, by the provisions of the Bengal Embankment Act, 1855 (Act 32 of 1855). In addition, sections 4, 5, 6, 34 and 76 of the Bengal Embankment Act, 1882 (Bengal Act 2 of 1882), are applicable to Orissa.

190. The Act of 1855 commences with a very brief definition of an embankment as an embankment for the purpose of excluding or retaining water. A more complete definition appears desirable and we suggest that the Act be amended so as to include the definitions of "embankment" and "public embankment" contained in section 3 of Bengal Act 2 of 1882, with the addition, in the definition of "embankment," of the words "all land, earth, pathways, gates, bermes and hedges belonging to, or forming part of, or standing on any such embankment." In particular, the omission of bermes from the definition has been found to give rise to serious difficulty in Bengal, and may be found to do so in Orissa also.

191. Section 3 of the Act of 1855 provides for the superintendence of all public embankments being entrusted to a Superintendent of Embankments, and section 4 gives the Superintendent power—

(*a*) to cause any embankment which adjoins public embankments or which is necessary for the protection of the neighbouring country to be taken charge of and be kept up by the officers of Government;

(*b*) to cause any private embankment, which endangers the stability of a public embankment, or obstructs the beneficial drainage of the country, to be removed;

(*c*) to change the line of any public embankment, or make a new embankment; and

(*d*) to enlarge any public embankment and do all acts necessary for its maintenance.

We consider that the Superintendent should also be empowered—

(*i*) to forbid repairs to be made to any embankment; and

(*ii*) to direct the owner of any private embankment to provide sluices or escapes in it, to such extent as he may determine, if the embankment obstructs the beneficial drainage of the country.

The first addition is highly desirable. In some cases, where an embankment has breached on a drainage line, it may be unnecessary to order the complete removal of the embankment provided that the breach remains open, but, under the existing law, it is extremely doubtful whether an order of the Superintendent to the effect that the breach shall not be closed would be legal. The second addition raises a difficult question. Certain embankments could be rendered innocuous by the provision of escapes or sluices in them, but the Act provides no means of securing the construction of such escapes or sluices unless Government takes over the whole embankment under section 4(1). As an alternative, the Superintendent could order the whole embankment to be removed, but, although this might possibly suit the owner better, if he obtained adequate compensation, it might result, especially in the case of salt embankments, in cultivated land going out of cultivation, which would be to the detriment of the country as a whole. The addition we have proposed is little more drastic than the power conferred by section 60 of the Bengal Irrigation Act, 1876, under which the Canal Officer may require the owner of a village channel to construct and maintain all works necessary for the passage of the drainage intercepted by it, and, in the event of the owner's failure to do so, may execute the works on his behalf and recover the cost from him. In the case of embankments, however, seeing that, in many cases, they have been in existence for long periods, we think that it might be provided that the owner shall pay only such part of the cost, not exceeding one-half, as Government shall decide, on the analogy of section 8(1) of the Act of 1855.

192. Section 5 of the Act of 1855 provides for notice being given by the Superintendent to the Collector of his intention to take action under section 4, for the publication of a proclamation incorporating the substance of the notice and calling upon all persons interested to appear, and for the procedure on the appearance of the parties. Under clause 3 of this section, if the Collector, after hearing the parties, differs from the Superintendent, the case must be referred to the Commissioner for decision. We suggest an amendment of this provision. We can foresee many cases in which the Superintendent of Embankments may differ from the Revenue Officers; they are each working in different interests. Indeed, a case was actually quoted before us in which, after an embankment had been abandoned by Government in the interests of the better drainage of the country, the zamindars were encouraged by the civil officers to repair it, in the interests of the local crops. We consider that, if there is a difference of opinion between the Superintendent of Embankments and the Collector, the case should be referred to the Commissioner who, if he supports the Collector's view, should forward it to the local Government for final decision. Similarly, clause 4, which provides for appeals from any order of the Superintendent being made first to the Commissioner and then to the Board of Revenue, should, we think, be amended to provide that, if the Commissioner disagrees with the Superintendent, he must forward the case for final decision to the local Government while an appeal from the Commissioner's orders supporting the Superintendent should lie to the same authority, and not to the Board of Revenue. There is machinery in the Secretariat to ensure that such cases will be placed before the Government with the full arguments of both sides.

193. Section 6 provides for the person who is bound to keep up an embankment being charged with the cost of its maintenance, even if it is taken over by Government. We imagine that it will be difficult to prove, in the case of the majority of embankments, that any person is " bound " to keep them up.

194. Section 7 deals with the question of compensation for acts done by the Superintendent in the exercise of his powers and the method of assessing such compensation; the procedure prescribed appears to us to be somewhat cumbersome and it is a question whether simpler means could not be devised.

195. Section 8 prescribes the amount to be paid as contribution by landholders, farmers, or cultivators who apply successfully for the construction of a sluice in a Government embankment. This amount is defined as " such part, not exceeding half the cost thereof, as may be determined by

Government." The word "cost" is indefinite and should, we think, be defined to include, firstly, such amount in respect of charges for establishment, tools and plant, and audit as the Government may direct and, secondly, a sum representing the capitalized annual cost of maintenance. In many cases there is no reason why the applicants should not bear half of the full real cost both of construction and maintenance; this is the maximum which can be demanded and it is always open to Government to take a smaller amount, if circumstances warrant it.

196. Sections 9 and 10 call for no remarks. In section 11, provision should be made for the reference of differences of opinion between the Commissioner and the Superintendent to the local Government. Sections 12 to 21 appear to require no amendments.

197. Coming now to the sections of Bengal Act 2 of 1882 which are applicable to Orissa, section 4 provides that all public embankments shall vest in Government. Mention is made in this section of Schedule D of Bengal Act 6 of 1873, which Schedule contained a list of all embankments for which Government had accepted full responsibility, and which, together with certain sections of that Act, remained unrepealed when the Act of 1882 was passed. The Schedule contained none of the Orissa Embankments and section 43 of the Act of 1882, which empowers Government to add embankments to or remove them from the schedule, has never been made applicable to Orissa. The position in Orissa in regard to this Schedule is thus not altogether clear. If, as we believe to be the case, Schedule D has no application to Orissa, it appears to us that some similar Schedule, having the force of law, should be prescribed, showing the embankments for which Government accept liability and to which Government should be empowered to add or from which they should be empowered to delete any embankment as occasion arises. Under the law as it stands at present, the power of Government to cease to maintain or to remove a public embankment does not seem to be clearly specified. If this suggestion be adopted, it will follow that the power conferred by section 4(1) of the Act of 1855 will vest in Government and not in the Superintendent of Embankments. The whole ambiguity points, we think, to the desirability of amending and consolidating the law, since so long as embankments are governed by a number of different Acts and isolated sections of Acts, inconsistencies are bound to creep in.

198. Section 5 of the Act of 1882 deals with the question of land used for obtaining earth for repairs. Section 6 gives Government power to notify prohibited areas within which no embankment may be constructed without the permission of the Superintendent of Embankments. It has been customary in Orissa to notify such areas by naming a particular river and prohibiting embankments within a mile of the banks; in the case of the Subarnarekha three miles have been prescribed. We do not consider that this form of notification goes far enough. In the first place, in the circumstances of Orissa, it is extremely difficult to define what should be regarded as the bank of a river; in the second place, it is almost impossible to notify every small stream, yet much damage is being done by the construction of embankments on such streams; in the third place, an embankment which crosses the surface drainage of the country may be even more harmful than one upon the margin of a river. We are of opinion that, for the present at least, the whole of deltaic Orissa should be notified as a prohibited area, but it should be open to the Superintendent to give a general permission to the construction of embankments, not exceeding a stated height to be determined by him, in specified areas, the fact that such an embankment is to be constructed being merely notified to him by the responsible parties for information and record.

199. Section 34 gives the Engineer power to enter neighbouring land and take earth for the repair of embankments.

200. Section 76, the last section of the Act of 1882 applicable to Orissa, is the penal section and provides for the punishment, by fine or

imprisonment, of an unauthorized interference with embankments or drainage both within and outside prohibited areas. There are two points which require notice in this connection. In the first place, there is often difficulty in finding the exact person responsible for the construction of an unauthorized embankment and we consider that, in such a case, the responsibility should be laid jointly upon all those benefited by the work, as is done in the case of the unauthorized use of water under section 79 of the Bengal Irrigation Act, 1876. In the second place, it is here that we find an extraordinary omission in the law. Section 79 of the Act permits the convicting Magistrate to order the removal of an unauthorized embankment or obstruction, but this section is inapplicable to Orissa and it follows that, while it is possible to secure the punishment of the person erecting an obstruction, there is no provision for getting such obstruction removed, unless it can be classed as a public nuisance. We have had the papers in the Bengal Secretariat leading up to the passing of the Act of 1882 examined to see whether there was any special reason for this omission but can find none; it appears to have been due to an oversight. It is an omission which should be remedied at the earliest possible date.

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CHAPTER XV.

Miscellaneous.

201. There are various matters which, before concluding our report, we deem it desirable to mention but which do not fall within the scope of any of the preceding chapters. It is to these matters that the present chapter will be devoted.

202. Several witnesses have referred to the probable effect upon the discharge of the rivers of Orissa of activities undertaken in the Feudatory States. These activities fall into three classes, namely, deforestation, the construction of small agricultural embankments on the tributaries of the main rivers, and the construction of larger embankments upon the main rivers themselves. Deforestation tends to increase the rate of run-off of water from the catchments and therewith the intensity of the floods experienced below. The danger in the agricultural embankments referred to lies in the fact that they are, in many cases, constructed one behind the other along the course of the tributary with the result that, if the upper one bursts, the embankments lower down the same stream burst successively, thus throwing the whole volume impounded suddenly into the river. We think that it would be well were representations made to the States, asking that a strict control should be maintained over such activities. There should also be a convention that the Superintendent of Embankments should be consulted before any further large protective works, such as the embankment now under construction along the bank of the Mahanadi in the Baramba State, are taken in hand.

203. We lay considerable importance upon the desirability of a close liason between the Superintendent of Embankments, the Railway, the Buildings and Roads Branch, the Irrigation Department, and local bodies. All projects affecting drainage which are put forward by any of these authorities should invariably be sent to the Superintendent of Embankments for scrutiny before they are carried out, and, if he is not satisfied that the drainage of the country is properly safeguarded, their construction should not be undertaken until the matter has been referred to the local Government. We may here remark that, so far as we have been able to ascertain, there is no ground for the opinion popularly held that the waterway given in the Bengal-Nagpur Railway, where it traverses Orissa, is generally insufficient. Three isolated cases in regard to which specific allegations have been made, namely, in the line near Jaleswar, near Balasore, and between Haldipada and Basta, might, however, be further investigated. The adequacy of the drainage of the small area in the triangle intersected by the railway near the bifurcation of the Katjuri and Koakhai might also be looked into.

204. There are many minor causes of obstructions on the various rivers which require to be kept in check. We have already referred to the leasing of drainage channels for fishing purposes, which results generally in the erection of *bandhs* across them, and the same remarks apply to the leasing of their beds for cultivation. A more efficient control is also required over the road crossings of the major rivers. These usually take the form of temporary causeways, constructed in some cases by contractors and in others by the Public Works or Khas Mahal Department. In themselves, they do but little harm, provided they are removed before the advent of the floods; this is, however, by no means always the case and we have noticed during our inspections that, in many instances, where they have not been completely removed, large volumes of sand and silt have been deposited behind their remains. The Superintendent of Embankments should prescribe the date by which such obstructions must be removed and, if they are not so removed, he should be empowered to remove them himself at the cost of the person or department making them.

205. From the statements of certain witnesses whom we examined there appears to be some ambiguity regarding the liability both of Government and the cultivators for the clearance of the approach and outfall channels to and from sluices, and we consider that this liability should be clearly defined. Subject possibly to an exception where the outfall channel is of considerable length, in which case the question should be decided on its merits, we think that Government should undertake to clear the outfall and that the clearance of the interior channel should be left to the cultivators.

206. During the past century an enormous literature has grown up around the subject of embankments in Orissa and their effects upon floods; so vast has it become that it is an exceedingly difficult and tedious matter to trace any particular reference or to obtain any general idea of the history of the question as a whole. It would, we think, be advantageous if the whole of the past records were scrutinized and carefully weeded, and if selections were then printed containing the more important documents, each volume being prefaced by a precis of its contents. Compilations of this nature would save a large amount of time and labour on the part not only of the officers in direct charge of the works but also of Government themselves.

207. Finally, our report would, we think, be incomplete without some reference to the thorny subject of finance. Our proposals involve heavy expenditure, both initial and recurring, not only upon works and establishment but also, so long as the law remains as at present, upon compensation to every individual adversely affected by the scheme. In so far as initial expenditure upon works of a capital nature, such as the Sur Lake cut, the raising of and provision of escapes in embankments to be permanently retained, etc., is concerned, we see no reason why it should not be met from loan funds and the cost thus spread over a number of years. There will still, however, remain a considerable recurring expenditure upon staff, works which cannot rightly be charged to capital and experimental work. It is essential, if our scheme is to be brought into operation at all, that those entrusted with its execution should be assured of a regular annual grant, so as to enable an orderly programme to be drawn up and pursued; this will be impossible if the grant is a fluctuating one determined not by the programme but by the competing demands of other departments. It has been suggested that, in order that Orissa may pay for Orissa, the grant might be provided from a cess leviable on land bettered by the scheme; this proposal is worthy of consideration although we are afraid that it may be found in practice that it is impossible to determine exactly which land has been benefited and to what extent, especially where the benefit is prospective rather than immediate. In view of the difficulties, both administrative and financial, which are probably inherent in it, we do no more than mention another suggestion which has been put before us to the effect that, for a term of years, part at least of the additional land revenue which will be charged upon Orissa under the settlement now taking place should be definitely earmarked to meet the recurring expense of the scheme and for the service of the loan.

208. As regards compensation, it seems to us that a law framed to apply to individual and exceptional cases may well prove impossible of application when the exception becomes the rule. If in our chapter on

CHAPTER XVI.

Summary of main recommendations.

209. We append below a brief summary of the main recommendations contained in the preceding chapters :—

(1) The embankments which form part of the canal systems should not be removed (paragraph 37).

(2) Systematic action should be taken to clear away obstacles to the free flow of flood water (paragraph 41).

(3) The Agricultural Department should attempt to popularise irrigation by pumping (paragraph 45).

(4) All embankments permanently retained should be such as to offer no obstruction to floods in excess of certain dimensions and should be secure from breaching (paragraph 46).

(5) Reclamation within tidal basins should be prohibited (paragraph 48).

(6) A new embankment should be constructed across the angle formed by the Bhograi and Joki embankments, and these embankments abandoned (paragraph 62).

(7) The *chak bandhs* at the mouths of the Haskura group of rivers should be removed or lowered (paragraph 65).

(8) A sluice should be provided for the drainage of the Salsa Pat (paragraph 66).

(9) Government drains should not be leased for fishing (paragraph 67).

(10) The Darburi embankment should be efficiently maintained (paragraph 68).

(11) Range III of the High Level Canal should be provided with breaching sections and terminated at the bifurcation near Bhadrak (paragraphs 72 and 73).

(12) Sluices should be provided at the heads of the Benga and Patpur Nalas (paragraph 74).

(13) The possibility of drainage channels from the Dhamnagar thana to the Matai should be investigated (paragraph 75).

(14) The Baitarani left embankment above the railway should be raised and an escape provided in it (paragraph 81).

(15) Both embankments of the Baitarani between the railway and the canal heads should be raised and an escape provided in the right embankment (paragraph 83).

(16) Range II of the High Level Canal should be abandoned (paragraph 84).

(17) A cut should be made to drain the area between the Baitarani right embankment above the Burha weir and the High Level Canal (paragraph 85).

(18) Ranges IVA, IVB and V of the Orissa Coast Canal should be abandoned (paragraph 91).

(19) The roads from Bhadrak to Chandbali and from Basta to Baliapal should be metalled with sufficient waterway in the shape of low vented causeways (paragraph 96).

(20) Certain feeder roads should also be improved and metalled (paragraph 97).

(21) The roads in this area should be treated as provincial roads (paragraph 98).

(22) A special investigation should be made regarding the salt embankment in the Balasore District (paragraph 99).

(23) The Brahmini weir should be removed (paragraph 105).

(24) The approach and outfall channels to and from the Kuaria and Mattagunjar Aqueducts in Range I of the High Level Canal should be cleared (paragraph 106).

(25) The shutters should be removed from the Pattia weir and a solid body wall substituted (paragraph 107).

(26) The Ganda embankment should be raised and an escape provided in it (paragraph 110).

(27) The Dudhai Canal should be abandoned (paragraph 112).

(28) The embankment on the left of the Brahmini below the weir should be taken over by Government, raised, and extended up to the weir. Escapes should be constructed across the Janardan and Manika *ghais*, and the Sahara and Bisai *ghais* filled in (paragraph 114).

(29) The Gajaria embankment on the Brahmini should be removed and the Uttikan embankment on the same river curtailed. All further reclamation in the Hansua estuary should be stopped (paragraph 118).

(30) The Aul circuit embankment should be removed and the road across the estate lowered (paragraph 123).

(31) The Damerpur circuit embankment should be removed (paragraph 124).

(32) Irrigation by pumping should be introduced in Aul and Damerpur (paragraph 125).

(33) The breaches in the Indupur tie *bandh* should not be repaired and the upkeep of the Gopalpur tie *bandh* should cease (paragraph 126).

(34) A regulating escape should be constructed from the Brahmini into the Chota Brahmini (paragraph 127).

(35) The Kendrapara Canal from Marsaghai to Jumbu might be abandoned (paragraph 135).

(36) All obstructions should gradually be removed from the Mahanadi and Daib islands except short detached embankment on their noses (paragraphs 137 and 151).

(37) Experiments in irrigation by pumping should be made on the Mahanadi and Daib islands. Isolated depressions on these islands should be drained by cuts (paragraphs 138 and 151).

(38) Reclamation in the Mahanadi estuary should be stopped and further reclamation prohibited (paragraph 139).

(39) The strictest control should be exercised in the area watered by the southern branches of the Mahanadi to prevent the construction of new and the raising or lengthening of old embankments (paragraph 145).

(40) The embankment where the Mankho *ghai* is located should not be taken over by Government. If the *ghai* reopens, an escape should be provided in it (paragraph 147).

(41) The Olanka should be re-opened, a high level escape being constructed across its head (paragraph 149).

(42) A special investigation should be made into the conditions around Kakatpur. The right embankment of the Daib should not be raised, nor should any further construction of private embankments be permitted within it (paragraph 152).

(43) The investigation should cover the question of improvements in the course of the Prachi (paragraph 153).

(44) Further experiments should be made in the matter of excavating cuts through the sand dunes to assist the rivers to discharge (paragraphs 26 and 155).

(45) The metalling and lowering of the Pipli-Nimapara road should be considered (paragraph 157).

(46) A drainage cut should be made from the Sur Lake to the sea (paragraph 160).

(47) The questions of a cut in the Sonamuhi and of opening the Naya Nadi should be investigated (paragraph 162).

(48) The Daya left embankment should not be raised, but it should be gradually abandoned, being in the meantime maintained in repair at its present height (paragraph 164).

(49) The Monaguni embankments should be discontinued two miles from the Daya (paragraph 165).

(50) The construction of a right embankment to the Daya should not be permitted (paragraph 166).

(51) The embankments on the Nuna and Ratanchira should on no account be restored (paragraph 167).

(52) No reclamation should be allowed in the bed of the Chilka Lake (paragraph 168).

(53) Measures should be taken, as necessary, to maintain an open mouth to the Chilka Lake (paragraph 169).

(54) A special Superintending Engineer should be appointed for the charge of embankments and drainage (paragraph 174).

(55) Two permanent divisions should be formed for the same purpose, the headquarters of one of which should be at Puri. A temporary division will also be necessary while construction is in progress (paragraph 176).

(56) Suitable means of conveyance should be provided for officers employed on embankments and drainage (paragraph 177).

(57) A contour survey of Orissa, including the running of main lines of levels, should be carried out by the Survey of India. The G. T. S. datum should be adopted throughout Orissa (paragraph 178).

(58) A survey should be made of all private embankments in Orissa (paragraph 179).

(59) The number of gauges in rivers and estuaries and on the sea face should be increased and readings scientifically taken and compiled (paragraphs 180 and 181).

(60) More rain-gauges should be provided in the Baitarani catchment (paragraph 182).

(61) Cross sections of the rivers should be periodically observed (paragraph 183).

(62) Discharges of the main rivers should be taken and discharge sites calibrated (paragraph 184).

(63) Special flood reports should be compiled (paragraph 185).

(64) The law relating to embankments should be revised and consolidated (paragraphs 187—200).

(65) The Feudatory States should be asked to maintain a strict control over deforestation and the erection of embankments in their areas (paragraph 202).

(66) All projects by any authority which affect drainage should be scrutinized by the Superintendent of Embankments. Certain allegations regarding insufficient waterway in the railway should be investigated (paragraph 203).

(67) Channels should not be leased for cultivation and control should be exercised to secure the removal of temporary road crossings (paragraph 204).

(68) The liability of Government and the cultivators for the clearance of sluice channels should be defined (paragraph 205).

(69) Selections should be printed up from the past records regarding floods in Orissa (paragraph 206).

(70) Arrangements should be made to ensure a regular annual grant for embankment and drainage work (paragraph 207).

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CHAPTER XVII.

Conclusion.

210. In conclusion, we desire to express our acknowledgments to all those gentlemen who took the trouble to give evidence before us, to send us written opinions, and to attend our meetings. The benefit of their advice and experience, which we were thus enabled to gain, has been of the greatest value to us in the prosecution of our enquiry.

211. Our acknowledgments are also due to those who so kindly assisted us in our tours by the provision of elephants and other means of conveyance in the remoter portions of the country. In particular, we are indebted to the Bengal Nagpur Railway Company who, by placing a special carriage at our disposal and permitting it to be attached or detached at any station at our request, not only greatly facilitated our railway journeys but afforded us accommodation at places where no other was available.

212. Mr. J. Shaw, who was appointed as our Secretary on the unfortunate break-down in health of Mr. Stevenson early in our first visit, has carried out his duties with much energy and success. During the interval between our visits he was engaged upon the making of surveys and the collection of information for us, work which involved considerable exposure and inconvenience during the most unfavourable months of the year. In spite of these difficulties the work was accomplished with commendable thoroughness and despatch and will, we believe, form a valuable starting point for the systematic observations which, we have recommended, should now be inaugurated.

213. Finally, we desire to express our special thanks to Mr. K. R. Bery, the Superintending Engineer of the Orissa Circle, who accompanied us throughout our tours and made all the arrangements for them. Of the 2,181 miles which we covered, 375 were accomplished by train, 724 by motor car (mostly over unmetalled roads), 594 by steam launch, and 488 by motor boat, elephant, rowing boat, trolley, *tanjam*, palanquin, and other means of conveyance. The organization of such tours involves an enormous amount of labour, and we can pay no higher tribute to Mr. Bery's arrangements than to say that both our programmes were carried through without a hitch. We are, further, indebted to him for giving us the benefit, in information and advice, of his long experience of Orissa and its problems.

CUTTACK:
22nd August 1928.

C. ADDAMS WILLIAMS.
BISHUN SVARUP.
D. G. HARRIS.
J. SHAW,
Secretary.

APPENDIX I.

Diary of Tours.

FIRST TOUR.

January 6th—Mahanadi weir. Embankments and gauges round Cuttack.

,, 7th—Along Machgaon Canal to Jagatsinghpur. Daib river at Alipingal. Olanka and Cross Katjuri spills. Returned *via* Jajpur and Taldanda Canal. Recorded evidence at Cuttack.

,, 8th—Naraj weir. Recorded evidence at Cuttack.

,, 9th—Recorded evidence at Cuttack.

,, 10th—Birupa weir at Jagatpur to Brahmini river at Dharmasala. Brahmini and Pattia weirs. To Akhuapada by High Level Canal, Range II.

,, 11th—Baitarani and Burha weirs. Right and left embankments of Baitarani. Meeting with Chief and Deputy Chief Engineers, Bengal Nagpur Railway. Inspection of railway line.

,, 12th—Jajpur Canal. Daserathpur on Baitarani and Binjharpur on Kharsua. Benga spill. Public meeting at Jajpur. Recorded evidence at Akhuapada.

,, 13th—Marcona, Basudebpur, Coast Canal, Range V, High Level Canal, Range III, Salindi embankment, and on to Balasore.

,, 14th—Coast Canal, Range V, at Chandipur. Recorded evidence at Balasore. Public meeting at Balasore. Interview with His Excellency the Governor.

,, 15th—Balasore to Bhadrak. Public meeting at Bhadrak. Coast Canal, Range V, at Charbattia, and on to Chandbali. Recorded evidence at Chandbali.

,, 16th—Dhamra estuary, Matai river and *via* Kharsua to Aul. Recorded evidence at Aul.

,, 17th—Inspection of Aul estate. Public meeting at Alba. Pattamondai Canal to Chota Brahmini spill *via* Gobri extension canal to Gandakia.

,, 18th—Jambu and Mahanadi estuary.

,, 19th—Returned to Gandakia, Chota Brahmini spill. Gobri canal to Kendrapara. Indupur breach and back to Pubhans. Recorded evidence at Pubhans.

,, 20th—Pubhans to Cuttack *via* Kendrapara Canal.

,, 21st—Recorded evidence at Cuttack.

,, 22nd—Recorded evidence at Cuttack. Public meeting at Cuttack.

,, 23rd—Cuttack to Puri. Koakhai, Kushbhadra, Bhargovi and Daya rivers. Kanti escape.

,, 24th—Recorded evidence at Puri. Public meeting at Puri.

,, 25th—Mouth of the Kushbhadra; Bhargovi, Dhanua and Patharbuha rivers.

,, 26th—Sonamuhi river. Recorded evidence at Puri. Meeting with Orissa Flood Conference Committee.

,, 27th—Sur Lake. Left Puri.

,, 28th—Arrived Balugaon. To Burkool. Chilka Lake.

,, 29th—Mouth of Chilka Lake.

,, 30th—Burkool to Balugaon. Recorded evidence at Balugaon.

,, 31st—Balugaon to Cuttack. Recorded evidence at Cuttack.

SECOND TOUR.

July 24th—Contai Road to Orissa Coast Canal. Bhograi.

,, 25th—Inspection at Bhograi. Coast Canal to Burabalong.

July 26th—*Via* Burabalong to Balasore. Coast Canal to Kansbans crossing.

,, 27th—Gumai crossing. Coast Canal to Charbattia. Matai river and on to Chandbali.

,, 28th—To Kharsua-Brahmini junction. Hansua creek

,, 29th—Aul Circuit and Raj Kanika.

,, 30th—Damerpur Circuit, Uttikan embankment, Albá and to western end of Aul Circuit—Gandakia.

,, 31st—Jumbu and Mahanadi estuaries.

August 1st—Paradip-Taldanda Canal.

,, 2nd—Arrived Cuttack.

,, 3rd—Halt Cuttack.

,, 4th—Daib river to Alipingal.

,, 5th—Left Cuttack.

,, 6th—Arrived Jenapur. Jenapur and Pattia weirs. Ganda embankment. Janardan *ghai*. On to Jajpur Road.

,, 7th—Junction of Kharsua and Pattia. Baitarani and Burha weirs.

,, 8th—Jajpur Road to Khurda Road. Daya river to Kanas and back to Delang.

,, 9th—Arrived Puri.

,, 10th—Jankadeipur. Down Bhargovi to junction with South Kania

,, 11th—Sonamuhi and Harachandi rivers to Mota.

,, 12th—Halt Puri.

,, 13th—Sardeipur and Achhutpur Escape. Arrived Cuttack.

,, 14/19th—Halt Cuttack.

,, 20th—Banki.

,, 21st—Halt Cuttack.

सत्यमेव जयते

APPENDIX II.

List of Witnesses.

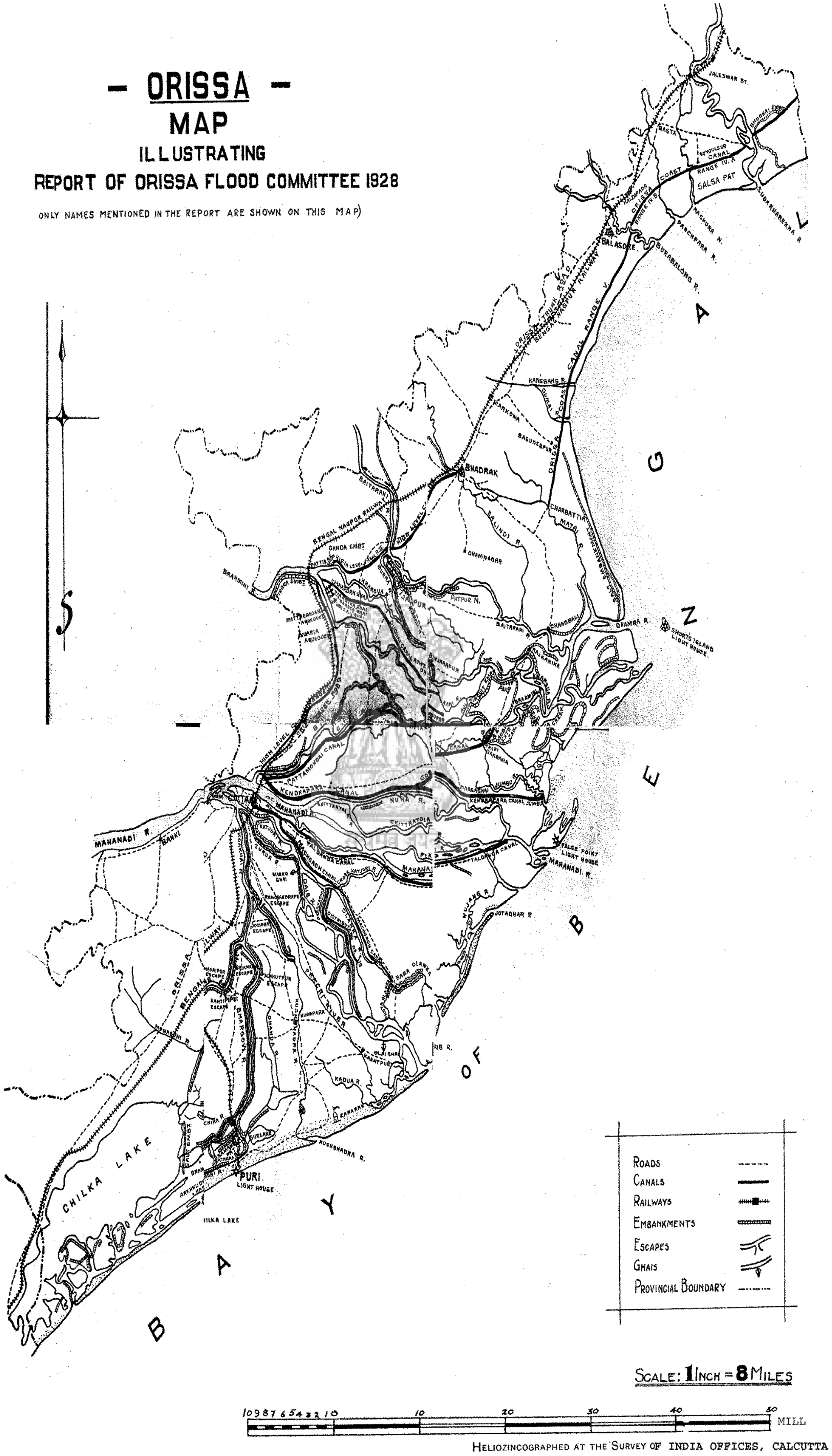
1. Mr. F. A. Betterton, late Superintending Engineer, Orissa Circle.
2. Mr. E. G. Beckett, Agency Engineer, Orissa Feudatory States.
3. Mr. D. R. Sethi, Deputy Director of Agriculture, Orissa.
4. Rai Sahib Madhu Sudan Chattarji, Executive Engineer, Balasore Division.
5. Mr. Leslie, Deputy Chief Engineer, Bengal Nagpur Railway.
6. Chowdhuri Bhagabat Prashad Samantarai Mahapatra, M.L.C.
7. Mr. Gopal Prashad Das, Chairman, district board, Balasore.
8. Mr. Jugannath Prashad Das, Vice-Chairman, district board, Balasore.
9. Mr. Nolini Mohan Chakravarti, District Engineer, Balasore.
10. Rai Sahib Profulla Chandra Patnaik.
11. Mr. Nand Lal Sinha, Civil Subdivisional Officer, Balasore.
12. Mr. R. P. Ward, I.C.S., Collector of Balasore.
13. Mr. Hari Krishna Mahtab, late Chairman, district board, Balasore.
14. Mr. Mukand Prashad Das, late Vice-Chairman, district board, Balasore.
15. Mr. Tej Chandra Pramanik, Civil Surgeon, Balasore.
16. Rai Bahadur Manmatha Nath De.
17. Raja Rajendra Narayan Bhanj Deo, O.B.E., of Kanika.
18. Mr. Braja Sunder Deb, Proprietor of Aul.
19. Mr. Syed Zaimuddin, Manager, Aul Estate.
20. Munshi Abdul Karim.
21. Mr. Jadumoni Mangaraj.
22. Rai Sahib Ajoy Chandra Das, Civil Subdivisional Officer, Kendrapara.
23. Rai Sahib Madhab Chandra Misra, Civil Subdivisional Officer, Sadr Subdivision, Cuttack.
24. Mr. P. T. Mansfield, I.C.S., Settlement Officer, Orissa.
25. Major C. G. Howlett, I.M.S., Civil Surgeon, Cuttack.
26. Mr. B. C. Sen, I.C.S., Commissioner, Orissa Division.
27. Rai Sahib Nibaran Chandra Ganguli, Executive Engineer, Mahanadi Division.
28. Mr. B. Das, M.L.A.
29. Mr. Lakshmidhar Mahanti, M.L.C., Chairman, district board, Cuttack.
30. Mr. Kunjabehari Ghose, District Engineer, Cuttack.
31. Mr. Birbar Narayan Chandra Dhir Narendra, Proprietor of Madhupur.
32. Mr. Banbehari Palit, Secretary, Orissa Landholders' Association.
33. Mr. Bhikari Charan Patnaik, Secretary, Orissa People's Association.
34. Rai Bahadur Dayanidhi Das, Collector of Puri.
35. Pandit Gopabandhu Das.
36. Mr. Brahmananda Mahanti, Vice-Chairman, Puri district board.
37. Mr. Golak Prashad Ray, District Engineer, Puri.
38. Rai Bahadur Dr. A. K. Mukherji, Civil Surgeon, Puri.
39. Mr. Tribikram Pujari, Civil Subdivisional Officer, Sadr Subdivision, Puri.
40. Mr. Nalini Kanta Mukharji, Manager, Kothdesh Estate.
41. Mr. N. F. Peck, I.C.S., Collector of Cuttack.

42. Mr. Banamali Das, Pleader, Puri.
43. Mahant Radha Charan Das.
44. Raja Radmohan Mansingh Harichandan Mardraj Bharamarbar Ray of Parikud.
45. Mr. P. J. Scotland, I.C.S., Assistant Settlement Officer, Orissa.
46. Mr. S. K. Roy, Executive Engineer, Roads and Buildings Branch, Cuttack division.
47. Mr. Rajendra Kumar Sen, Sub-Manager, Kujang Estate.
48. Mr. K. R. Bery, Superintending Engineer, Orissa Circle.

सत्यमेव जयते

– ORISSA –
MAP
ILLUSTRATING
REPORT OF ORISSA FLOOD COMMITTEE 1928

ONLY NAMES MENTIONED IN THE REPORT ARE SHOWN ON THIS MAP)



Scale: 1 Inch = 8 Miles

Heliozincographed at the Survey of India Offices, Calcutta